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HISTORY OF THE PARACHUTE.

THE invention of the parachute is generally attributed to Garnerin, but this is an error, for Sebastien Lenormand, in 1783, threw himself from the tower of the Montpellier Observatory by means of a parachute of his invention. Blanchard, the well known aeronaut, made use of parachutes to send down from his balloon sheep, dogs, rabbits, and cats, which he abandoned in space to the great delight of his spectators; but the idea of the parachute had been proposed by inventors long before him. But Garnerin was the first to construct a parachute of large dimensions, capable of descending from a great height and of sustaining the weight of a man in the air. He had the courage to trust himself to his apparatus. He undertook a series of experiments, which, for many years, incited the astonishment and admiration of the public to the highest degree. A pupil of the physicist Charles, he embraced revolutionary ideas. Sent as commissary to the Army of the North, he was taken prisoner in a battle at Marchiennes. For years the Austrians kept transferring him from prison to prison, and he conceived the idea of making his escape by means of a parachute.

The love of liberty, says he, in the programme of his first parachute descent, so natural to a prisoner, more than once inspired me with the desire of breaking loose from my rigorous detention. To surprise the vigilence of my sentinels, to break the huge iron gratings, to pierce walls ten feet in thickness, and to precipitate myself from a rampart without being dashed to pieces, were projects that sometimes served me as a recreation. Blanchard's idea of exposing wide surfaces to the air for neutralizing, through its resistance, the acceleration of motion in the fall of bodies, seemed to me to have need only of a good theory in order to be employed with success. I applied myself to the laying of the bases of it. After determining the dimensions of a parachute for descending from the top of a rampart or from a very steep mountain, I ascended by a natural progression to the proportions that should be given to a parachute designed for an aerial traveler whose balloon might happen to burst at a height of ten or fifteen thousand feet.

As soon as he was set at liberty, Garnerin carried out the enterprise that he had so long meditated upon in prison. The astronomer Lalande has given a description of this memorable experiment, which is represented in Fig. 1. We borrow from him the following account of it:

On the 22d of October, 1797, at twenty-five minutes past five in the afternoon, Citizen Garnerin ascended in a free balloon from Monceau Park. A gloomy silence reigned in the assemblage, and interest and inquietude were depicted upon every countenance. After he had exceeded the height of 2,200 feet, he cut the rope that connected his parachute and car with the balloon, when the latter burst and the parachute under which Garnerin had placed himself very rapidly descended. It took on so frightful an oscillatory motion that a cry of terror escaped from the spectators, and some sensitive women were made sick. Meanwhile Citizen Garnerin descended in the Monceau plain amid an immense crowd, which testified its admiration for the talent and courage of the young aeronaut. In fact, Citizen Garnerin is the first who has dared to undertake this hazardous experiment. I went to announce the success of it to the National Institute, which was in session, and I was listened to with extreme interest. The experiment was often renewed by Garnerin, and eventually by his brother, and especially by his niece, Eliza Garnerin.

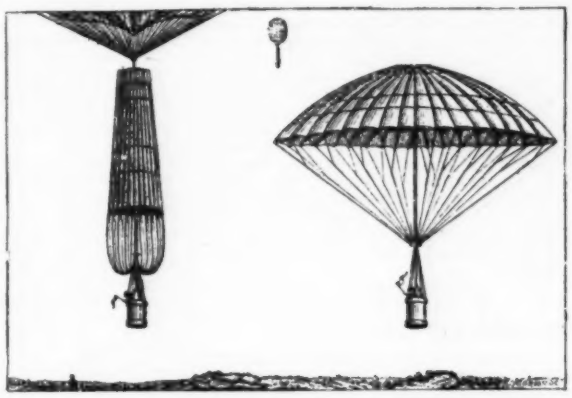


FIG. 2.—EXPERIMENT WITH A PARACHUTE MADE IN ENGLAND BY GARNERIN, IN 1802.

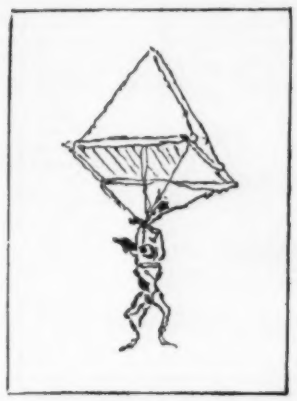


FIG. 3.—PRINCIPLE OF THE PARACHUTE.

Fig. 2, which represents an experiment made in England in 1802, gives the arrangement adopted by Garnerin. The parachute was attached to the lower part of the balloon, from which it could be detached by means of a cord. At the moment of the separation, the balloon, lightened by a considerable weight, rose very rapidly and sometimes bursted in the air. The parachute, left to itself, expanded and slowly descended to the earth, offering the majestic spectacle of the soaring of a vast apparatus in the atmosphere. It was at the time that balloons made their appearance in 1783 that Lenormand, of whom we have already spoken, devised a conical parachute, by means of which he was able to cast himself from the tower of the Montpellier Observatory. This experiment took place on the 26th of December, 1783, but was not repeated.

The idea of the parachute, moreover, is found much further in the past. It dates back to Leonardo da Vinci, the learned engineer and celebrated artist of the Renaissance, who occupied himself much with aerial locomotion, and who has left a project for a helicopter in his writings.

By consulting the *Saggio delle Opere de Leonardo da Vinci*, at the chapter entitled *Leonardo litterato e scienziato*, and the photolithographic plates that accompany it, it may be seen that the great artist had studied the method of measuring the stress that can be exerted by striking the air with blades of definite dimensions, and that he had invented the parachute, a drawing of which is given by him, and which is reproduced in Fig. 3. He describes the apparatus in a few lines, of which the following is a literal translation:

If a man has a tent of starched cloth, of which each face is 72 feet in width and which is 72 feet in height, he will be able to throw himself from any great height whatever without any fear of danger.

Leonardo da Vinci's description was reproduced later on, not without a notable improvement in the mode of representation of the apparatus, in a collection of machines due to Fautso Veranzio, published at Venice in 1617. Fig. 4 gives an exact reproduction of the parachute that the author defines in the following terms, which are assuredly inspired by those of Da Vinci:

With a square sail extended with four equal rods, and to the four corners of which four cords have been attached, a man will be able to throw himself without danger from a tower or any other high place, for, although at the time there be no wind, the effort of him who falls will bring wind that will hold back the sail so that it will not fall violently, but will gradually descend. The man must then measure himself with the size of the sail.

It is impossible to give the principle of the parachute more distinctly, and the apparatus is so clearly explained that it seems curious to us that the experiment indicated successively by Leonardo da Vinci and Fautso Veranzio was not tried. It will be seen that it was possible to perform it two hundred years before that of Garnerin.

We must now proceed to the end of the eighteenth century, at the epoch of the discovery of balloons, in order to find traces again of the history that we here resume.

A few months after the memorable experiment on the ascension of a hot air balloon made by the Montgolfier brothers at Annonay, Sebastien Lenormand, an inhabitant of Montpellier, made the following curious experiment in the inclosure of the Cor-

FIG. 1.—EXPERIMENT WITH A PARACHUTE MADE BY GARNERIN IN 1797.

deliers, on the 23d of December, 1783. He threw himself from the top of a branchless elm, holding in his hands two parasols of 30 inches radius. This tree presented a projection at the height of a first story, and it was from this that the inventor let himself drop.

A short time afterward, Lenormand constructed a genuine conical parachute, which he describes as follows: "I make a ring 14 feet in diameter with a thick rope, and all around it I firmly attach a canvas cone 6 feet in height. I line the cone with paper, which I glue to the canvas in order to render it impermeable to the air; or, better, instead of canvas, I use taffeta covered with gum elastic. All around the cone I place

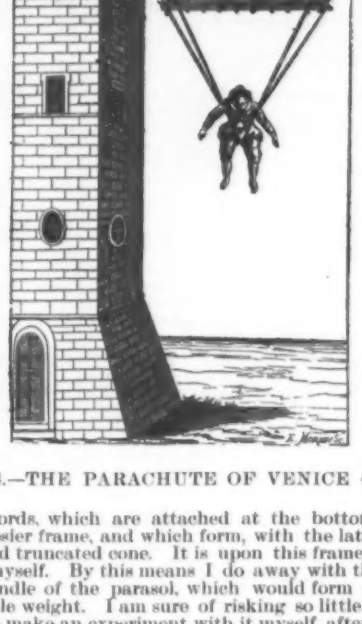


FIG. 4.—THE PARACHUTE OF VENICE (1617).

small cords, which are attached at the bottom to a small osier frame, and which form, with the latter, an inverted truncated cone. It is upon this frame that I place myself. By this means I do away with the ribs and handle of the parasol, which would form a considerable weight. I am sure of risking so little that I offer to make an experiment with it myself, after, however, testing the parachute with various weights in order to assure myself of its strength."

It was with an apparatus of this kind that Lenormand, as we have already said, succeeded at the beginning of 1784 in throwing himself with a parachute from the top of the tower of Montpellier. After the aerial voyages made at the end of 1783 by Pilatre de Rozier and D'Arlandes in a hot air balloon, and by Charles and Robert in the first gas balloon, Blanchard, who had already formed projects of aviation before the discovery of balloons, entered in his turn upon the career of aeronautics, and conceived the idea of providing the balloon, at its lower part, with a true parachute designed to moderate the descent. The car of

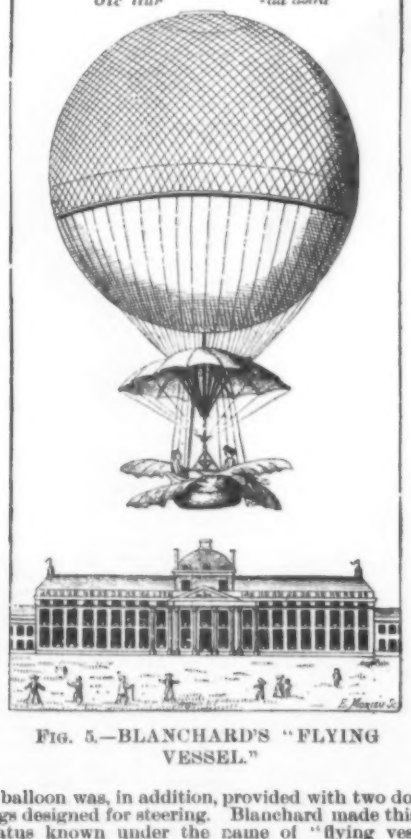


FIG. 5.—BLANCHARD'S "FLYING VESSEL."

the balloon was, in addition, provided with two double wings designed for steering. Blanchard made this apparatus known under the name of "flying vessel." Fig. 5 gives the aspect of it from a print of the period. The ascent of the apparatus took place at the Champ de Mars on the 2d of March, 1784, in the presence of an enormous crowd of spectators. The steering wings gave no result, but it is interesting to find that Blanchard constructed a genuine parachute, which was fixed to the lower part of the balloon. A little later on, in the course of his numerous ascensions, Blanchard took with his balloon complete parachutes, with which he sent down dogs or cats, and sometimes sheep, to the earth. Fig. 6 represents Blanchard's eighteenth aerial trip. The following is the legend that accompanies the engraving:

"Mr. Blanchard, citizen of Calais by adoption, pensioner of His Most Christian Majesty, and correspondent of several academies, having been called to the city of Brussels, went thither at the instance of the inhabitants, and made a glorious ascension there in the presence of Their Royal Highnesses and a numerous assemblage. He ascended amid a general acclamation on Saturday, June 10, 1786, at ten minutes past ten, and hovered majestically over the city for half an hour. On reaching the height of the clouds, he sent down a sheep, which, by means of his parachute, gently touched the earth, and the balloon tranquilly descended in a field called The Balloon."

It will be seen that Blanchard made use of a small special balloon for lifting the parachute. When it was a question of allowing the latter to descend, he had only to separate it from the small balloon, which he set at liberty in space.

Blanchard's name must be inscribed alongside of Garnerin's in the history of the inventors of the parachute, but, as we have already seen, Garnerin was the first who dared to intrust himself to the apparatus.

The modifications that have been introduced into the parachute (save those of Capazza) since Garnerin's time have not been happy. On the 27th of September, 1836, Coking was killed in making an experiment with a parachute in the form of an inverted cone. In 1853, Letur met his death in using a parachute provided with two steering wings. In 1874, De Groof lost his life in experimenting with a flying parachute of his invention. We shall terminate this study with the observation that the parachute has never served up to the present, except as the object of a curious experiment. It offers no practical utility to the aerial traveler. It, nevertheless, constitutes an apparatus of the greatest interest from a scientific point of view. It must be considered as the first aeroplane, and we know that it is from aeroplanes that aviation awaits its future.—*La Nature.*

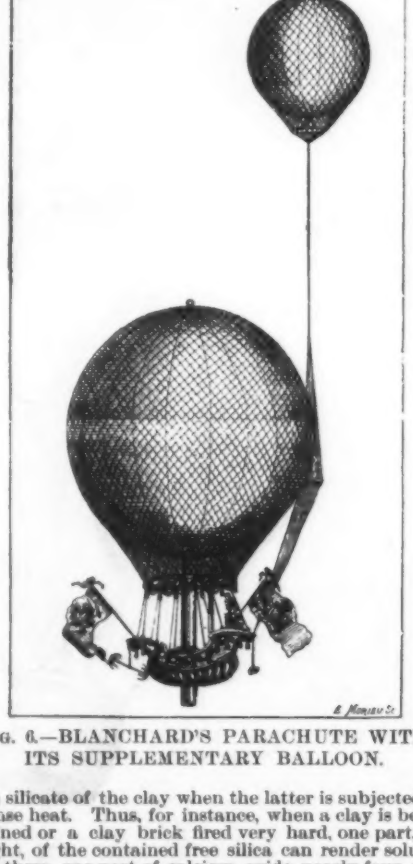


FIG. 6.—BLANCHARD'S PARACHUTE WITH ITS SUPPLEMENTARY BALLOON.

IMPROVEMENTS IN LININGS FOR STEEL FURNACES AND MELTING VESSELS.

A RECENT patent to Alexander D. Elbers, of Hoboken, N. J., relates to a process for treating comparatively pure clay, such as kaolinite or kaolin, for lining the hearths of metallurgical furnaces and the inside of melting vessels, and for similar uses.

The prime object of this invention is to provide a refractory material which is comparatively proof against corrosion by liquid-melted monosilicate slag that consists, as does the slag of many iron ore smelting or so-called "blast" furnaces, essentially of silicates of the earthy and earth metal bases. As such blast furnace slag carries only small quantities of alkalies, it cannot dissolve the essential constituent of a clay (considered as dehydrated aluminum silicate of the composition $Si_2Al_2O_7$) to any appreciable extent; but it attacks eagerly the free silica, free basic oxides, and other fluxible accidental constituents of which the purest washed clay usually still contains in the aggregate several per cent., and it also dissolves in its molten condition those fritted compounds to which several of these constituents unite with portions of the aluminum silicate of the clay when the latter is subjected to intense heat. Thus, for instance, when a clay is being calcined or a clay brick fired very hard, one part, by weight, of the contained free silica can render soluble over three, one part of calcium oxide nearly four, and one part of magnesium oxide over five parts of the aluminum silicate of the clay. Hence it seems evident that even the purest commercial clay would, when used for a hearth lining, be cut away rapidly by molten slag of the kind referred to and of monosilicate or of approximate basic constitution. That the lining of the blast furnaces in which such slag is made holds out against corrosion as long as it usually does is partly due to the more or less frequent formation of a sticky coating of agglomerated slag, metal, and coke, or coal dust, which, on account of its contents of infusible carbon, redissolves but slowly, and thus prevents the liquid melted slag from coming in direct contact with the lining; but its duration is chiefly owing to the circumstance that the saturating energy of the liquid basic blast furnace slag is considerably blunted by the sulphides which it always carries. These sulphides, which are in intermolecular combination with the slag, vitiate it also for the many profitable uses to which it might otherwise be put, whereas those kinds of blast furnace slag that are too acid to absorb sulphur have, on the other hand, neither a measurable value for direct utilization nor for manufacture. The problem how to desulphurize blast furnace slag in an economical manner is, therefore, an important one. Its solution lies apparently in the direction of desulphurizing the slag in its molten state in a reverberatory furnace; but the hearth which is to be used for such a purpose will require a much more refractory lining than the blast furnaces have, because the desulphurizing process does not involve the formation of carbonaceous deposits that could protect it against corrosion and because the corroding propensity or saturating energy of the slag intensifies considerably in the measure in which the sulphur is expelled from it. This requirement will, I believe, be fully met by my invention.

The invention consists in treating suitable clay with a flux that will combine wholly or in part with the fluxible accidental constituents of the clay when the mix of clay and flux is intensely heated, and in heating and working such a mix until its fusible portions become separated wholly or in part from the infusible ones.

The process can be carried out as follows: For a flux I use by preference desulphurized and otherwise purified blast furnace slag of monosilicate or approximate constitution—a material that is best made from "slag wool" or so-called "mineral wool"—by the aid of a process for which United States Letters Patent No. 278,002, dated May 22, 1883, have been issued to me. This flux is an impalpable powder with which the clay that is to be treated must be thoroughly intermixed. It reacts at a less elevated temperature on those accidental constituents that can combine chemically with the essential constituent of the clay than they require to unite with it. The critical temperature at which the fluxible accidental constituents of the clay frit together with the admixed flux in preference to uniting with the aluminum silicate sets in at about red heat. The fritted compounds that are then formed melt at about white heat, and they can become sufficiently thin fluid to percolate the mass and to exude from it, provided that the flux has been admixed in such proportions that its constitution will only be raised from a monosilicate to a sesquisilicate ratio or thereabout in the event it absorb all of the clay's fluxible matter. Thus one per cent. of free silica contained in the clay will require of the flux about five and a half parts, by weight, in order to form sesquisilicate, and one per cent. of orthoclase feldspar will require about one and three-quarter parts of it; but as the clay usually contains, also, some remnants of basic impurities, the latter offset to some extent the quantity of flux that is required for the acid ones. The most suitable proportions of admixture are, however, most easily determined experimentally by melting tests.

The clays that are best adapted for the treatment herein described contain from two to five per cent. of fluxible accidental constituents (mostly acid ones), and the proportion of flux that is required for their treatment is apt to vary between ten and fifteen per cent. of the weight of the dry clay.

I now proceed to describe the different operations. The clay is mixed with water until it assumes the consistency of a thick slip, and the flux is gradually stirred into the slip. The latter is then dried until it becomes a stiff paste, and the paste is best formed by hand into perforated balls of from two to four inches in diameter. These balls are thoroughly dried in any convenient manner and then are piled in heaps on the sole or hearth of a heating furnace. The heating furnace should be capable of enduring about as high a heat as that at which wrought iron melts. The hearth should be lined at first with calcined and ground kaolinite that has been mixed with tar. Later on this lining can be repaired or replaced with the new materal herein described. The heat is conducted as follows: The charge, consisting of the aforementioned perforated balls, is kept at the critical "fritting" temperature as long as may be found necessary—probably for about an hour. Then the furnace is fired harder until the balls melt down and spread out to a pasty mass. When this melting heat grows still more intense, then the fluxed impurities exude gradually from the mass, gather in pools on top, or flow off. That which flows out is hereinafter referred to as the "slag." This slag percolates and collects rather slowly, because its specific gravity does not differ much from that of the fining mass. Hence it may be advantageous to rake or work the charge somewhat, which is best done with a hard-burned scraping tool made of fire clay and having a hollow stem into which an iron bar can be inserted. The charge can also be banked in such manner that the slag must gather on top of the spreading charge until it overflows the bank, from whence it may then be discharged through the work hole or through an extra tap hole provided for that purpose. The slag is apt to be quite vitreous and sufficiently transparent when suddenly cooled to render clay particles visible that may have remained suspended in it. It can be used to advantage for making colored glass, and possibly, also, for making up a sulphur-free slag for various metallurgical purposes.

The progress of the heat can be easily ascertained by examining small test pieces that have been drawn out of the fining charge and chilled in water.

The heat is finished when the fractured surfaces of the test pieces are comparatively free from vitrified particles and of a rather homogeneous stony appearance.

The finished charge should also be chilled. It must either be broken out of the hearth, in which case it can be chilled by injecting water into the furnace, or it can be raked out while still very hot.

The chilled pieces should be assorted after having been crushed to about egg size. The unsound pieces

can be reburned with the next charge. The sound ones are to be ground coarse or fine, according to requirement, and the ground stuff is ready for use.

The material thus prepared I call "pyroconcentrates of fluxed clay." Its distinguishing characteristics, as compared with merely calcined clay substance, are as follows: The pyroconcentrates of fluxed clay consist, practically, of aggregates of aluminum silicate molecules that are bound together by vitrified remnants, mostly in the form of very thin films of the liquefied slag. When a comminuted mass of such concentrates is intensely heated, these vitrified particles resoften to some extent and then act as a mechanical bond without reacting, chemically, on the aluminum silicate. Granting that a lining which contains such remnants of the liquated slag may be attacked by a bath of liquid melted monosilicate slag, it stands to reason that the ensuing corrosion cannot be very energetic, considering that the silicate constitution of the slag bath does not differ much from that of the slag remnants of the lining. Pure clay substance, on the other hand, contains nothing that could bind it under heat, and if a clay does frit together in calcining, this chemical action is evidence that the calcined mass contains sufficient soluble matter to become readily decomposed by a corrosive slag bath. The pyroconcentrates can be applied in the usual manner after mixing with tar, etc., for lining the inside of melting vessels and furnaces, as a top dressing for linings made of other material, and for the manufacture of tuyeres, crucibles, and other refractory products. Its proper application as a hearth lining allows, as already explained, of holding and manipulating a thin fluid slag, which is so corrosive that it readily destroys the acid, as well as the basic and so-called "neutral" linings that have been thus far devised. This feature may also give rise to an important improvement in the manufacture of steel, inasmuch as a decarbonized steel bath can be purified from remnants of sulphur and phosphorus by bringing it into intimate contact with thin fluid desulphurized blast furnace slag. That such slag readily absorbs ferrous sulphide bodily—*i. e.*, holding it in intermolecular combination—and that it readily combines, chemically, with phosphoric oxide and phosphates is well known; but, in order to desulphurize the slag and in order to utilize the desulphurized slag for the indicated purpose, the suitable hearth lining material had first to be devised.

The mechanical portion of the herein described method of treating clay allows obviously of many modifications that are determined in actual practice—as, for instance, the most suitable shape and sizes of the pieces that are to constitute the charges and the manner of forming them, the most suitable devices for furthering the overflow of the slag from the fining charge and the arrangement of the hearth, which will be most advantageous for facilitating the separation of the slag from the fining charge—such modifications depending chiefly upon the capacity and construction of the furnace plant that is to be used and on the volume of the charges that are to be treated.

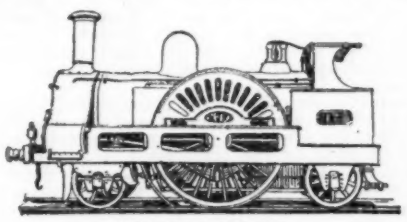
CLAIMS.

1. The herein described process of treating clay for the lining of metallurgical furnaces, etc., which consists in intermixing suitable clay with a flux which, if admixed in suitable proportions, combines with the fluxible accidental constituents of the clay to a thin fluid percolating slag when the mix is heated to about white heat; in preparing the mixes of clay and flux by forming and drying for the heating operation; in subjecting the prepared charges on the hearth of a suitable heating furnace first to a fritting heat and then to a melting heat; in furthering the outflow and removal of the slag from the melting and molten charges by suitable manipulation; in drawing and chilling the finished charges, and in preparing them for use by crushing, assorting, and grinding.

2. As a new article of manufacture, pyro-concentrates of fluxed clay, consisting of particles of dehydrated aluminum silicate holding remnants of a liquated flux in mechanical combination, substantially as described.

A FAMOUS LOCOMOTIVE.

IT is remarkable that one of the fastest, if not the fastest, engine now running was built forty-five years ago. She was designed when the great competition between the now vanished broad gauge and the narrow gauge was at its height. The Great Western on the broad gauge had beaten all records by upon several occasions obtaining a maximum speed of seventy-eight miles an hour, and it was necessary to beat her on the narrow gauge. The result was the building by Mr. F. Trevithick, superintendent of the northern division of the London and Northwestern Railway, of the Cornwall. Her driving wheel was made six inches larger than that of the Great Western, which



THE CORNWALL.

Built 45 years ago with the largest driving wheel in the world.

was 8 ft. in diameter. Mr. Trevithick, in order to obtain a large driving wheel and a low center of gravity, adopted the peculiar plan of placing the boiler under the driving axle. The driving wheel of 8 ft. 6 in. was the largest size which had then, or has since, been tried upon the ordinary 4 ft. 8½ in. gauge, the cylinders being 17½ in. diameter and 24 in. stroke. The engine appears to have fully answered the expectation of her designer, for upon the trial trip a speed of fully seventy-nine miles an hour was attained under favorable circumstances, thus beating the Great Western by one mile an hour. She was shown at the exhibition of 1851, but the position of her boiler was not approved, and in 1863 a new boiler was put in her above the axle. We give a sketch taken from Mr. Stretton's "Locomotive Engine and its Development," and it is interesting to know that the engine is still working the forty-five minute expresses between Manchester and Liverpool, one of the fastest services in the kingdom, and it is stated that still, after her forty-five years' service, with a load equal to her power, she is capable of running at the highest possible speed yet attained.—*Daily Graphic.*

STEAM FIRE ENGINE FOR BOMBAY.

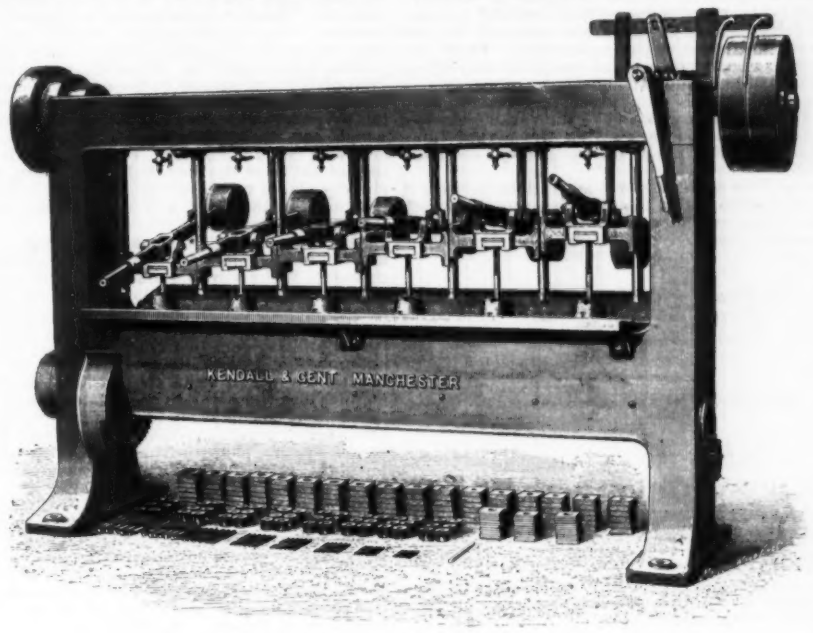
THE fire engine illustrated is one of a series of five recently made by Messrs. Merryweather & Sons for the Bombay municipality. In general design, says the *Engineer*, it is similar to those constructed by them for the Metropolitan Fire Brigade, but of greater capacity. In order to reduce unnecessary weight the usual gun metal distance piece between the pump and cylinder is replaced by three turned steel stays, the two upper ones carrying the crank shaft bearings. The bent crosshead, a specialty of the makers, is used, so that while the whole machinery is short and compact, a long connecting rod is admissible, which insures much freer running than could be obtained by a slotted crosshead or other arrangement usually used to shorten up the engine. A twenty foot length of suction, not shown, is carried on the engine, always attached to the pump, and the delivery outlets are fitted for improved instantaneous couplings.

A light fly wheel of large diameter is provided, in order that the engine may be worked at slow speed if required. The outside of the pump is triangular, and the two side covers are made removable in one piece with their respective valves. The pump is also fitted with a by-pass in case it is required to work from a limited water supply or through long lines of hose. A large hose box, forming seats for firemen, is fitted on the front of the engine, and the whole of the machinery is accessible from the back, so that the stoker can attend to the fire and the engine without moving from his post in the rear.

Our illustration shows the various points alluded to, and the whole forms a light, powerful machine, and is capable of delivering water under high pressure, 360 gallons per minute.

IMPROVED NUT TAPPING MACHINE.

WE illustrate herewith an improved type of vertical nut tapping machine, possessing several novel features and constructed by Kendall & Gent, of Manchester.



IMPROVED NUT TAPPING MACHINE.

In vertical nut tapping machines, as hitherto made, the taps are driven from above, and after passing through the nuts they fall out of their holders into the trough with the lubricant, cuttings, nuts, etc., which very frequently results in damage to the taps and the very unpleasant necessity of the attendant having to "fish" out the taps from among the oil, cuttings, nuts, etc., in the trough, and reinsert them in the holder for each nut. In the machine illustrated above the operation is entirely reversed, so as to obviate all these defects, and also the great loss of time resulting from them. The taps, as will be seen from the engraving, are driven from below, and the nuts are passed on to them, until the shanks of the six taps, with which the machine is fitted, are full, so that the taps only require lifting out about once every six nuts, to allow them to fall off the shank.

This type of construction allows also of perfect lubrication, as the oil from the lower cistern is pumped by the machine into the upper one, and pipes being fixed over the center of each tap, a constant stream of oil is kept flowing down the grooves of the taps, insuring perfect lubrication.

These machines, which are of very substantial construction, form very compact designs, the driving apparatus, stop motions, etc., being entirely self-contained.—*Practical Engineer.*

ON THE TRANSMISSION AND DISTRIBUTION OF POWER IN MODERN SHIPS.*

By NABOR SOLIANI, of the Italian Admiralty.

IN modern ships steam power is used not only as a propelling agent, but also to execute a great variety

* We are indebted to Messrs. Wighham, Richardson & Co., of Newcastle-on-Tyne, for the translation of this paper.

IMPROVED STEAM FIRE ENGINE.

of other operations which in old ships were either not done at all or performed by hand. Thus, on board merchant ships, a portion of the disposable power in the boilers is now employed to control the rudder, to weigh the anchor, to ventilate the ship, and to light it, to load and unload cargo, to pump the water, etc., and on board men-of-war, in addition to this, its employment is still greater, viz., for the working of artillery and torpedoes, the service of ammunition, etc. For each of these services to be executed in different parts of the ship, there is one or more special apparatus to be furnished with the power supplied by the boilers on board in one way or in another. There are several means employed, or that could be employed, to attain this object, and the choice of a proper system of power distribution is of a great importance, both for the efficiency and regularity of the various services on board ships and the economy in the actual function of the same, which tells on the general economy of the ship.

To give an idea of the importance of these services it will be sufficient to notice the following table, in which are indicated the auxiliary machinery to be found on a large modern ironclad, as, for instance, the Re Umberto.

Number and Power of Auxiliary Machinery in a First-Class Man-of-War.

Machinery.	Number of Machinery on Board.	Power Indicated in Horses for each Machine, Full Force Used.	Total Power.
Main hydraulic pumps	2	160	320
Secondary pumps			80
Steering gear			200
Main capstan			100
Warping capstans			100
Dynamos			100
Compressed air pumps	2		60
Fire engines	2		60
Circulating pumps	4		240
Main feed pumps	4		160
Auxiliary pumps	6		240
Bilge pumps	4		120
Exhaust pumps	2		140
Forced draught for boilers	12		240
Ventilating engines	8		80
Turning gear (for main engines)	2		50
Starting gear	2		50
Pumps for auxiliary condensers	2		40
Ash hoists	6		30
Workshop engine	1		10
Total	60		3,480

Of course these machines do not all work at one and the same time, nor at full power, and it is doubtful if, even during a combat, the collective power in action of the secondary engines would reach the half of the total power before indicated; but being even reduced to so much it is always considerable. Power may be supplied to these apparatus:

1. Either by rigid or flexible mechanical transmissions, that is either by shafting or otherwise, by ropes and by belts, and so forth.

2. By steam; in such case each apparatus must have its own steam engine.

3. By pressure water; and then a central steam engine is required in order to pump the water, and also hydraulic engines at the points where the power has to be utilized.

4. By compressed air; and as in the preceding case, it will be necessary to have a central engine to produce compressed air, and each apparatus must have its own engines acting by compressed air.

5. Lastly, by electricity, with a central engine generating the electric current and electric motors at the operating points.

Now since the power comes from the steam in the boilers, steam is evidently the most direct and simple medium to convey and distribute it to where power is wanted.

We may have to change the form of this power, which in the boilers is in a thermic state, and so we shall the various kinds of apparatus necessary for the transformation we require to produce. Although the development of the power may by this transformation be made longer and more complicated, yet in many cases in the new form it is better adapted to the action it is intended to produce, or affords some other advantages which make it preferable.

In men-of-war, especially, power is already developed and utilized in different degrees, in several different forms, and this is the case because to light by electricity we require electric engines, and to cause torpedoes to move we require pumps to charge them with compressed air, and so on.

I propose, therefore, to examine the merits and defects of these several different forms, and the extent to which each may be applied, so that we may determine which is the best adapted to each individual case.

Power Transmission and Distribution by Means of Shafts, Gearing, etc.—This system of power transmission and distribution is not possible on board ships, except on a very limited scale, and in fact it is only used in the workshop for the few machine tools, and in the working of the rudder.

Did we wish to extend it further, even without taking account of the considerable weight of shafts and the great losses by friction, this system would entail a complication of gearing, blocks and belts such as to make it quite impracticable. Far more practicable, on the contrary, are the other systems to which I will now turn my attention.

Power Transmission and Distribution by Means of Steam.—The system of transmitting and distributing the power by means of steam is, as we have already stated, the simplest of all, as also the one most generally employed. In the mercantile navy especially, with the exception of a few ships, which use hydraulic apparatus to load and discharge cargo, all the rest use steam for the various machinery and secondary apparatus on board. Even in the Royal Navy steam machinery takes the lead, hydraulic machines being, as it were, confined to heavy artillery only. With steam no other intermediate medium is required between the source of power and the working machinery, and therefore the action of these machines is completely independent of other apparatus. As long as the boilers are working and the circuit of the steam is in good order, all the working machinery can continue acting, and if any one part should get out of order, the work of the other machine will not be affected. We may also add that steam is a very pliable moving agent, that is to say it can generally be well adapted to any special conditions in which it has to act, especially when used, as is now general, at a high pressure. Against the above advantages must be set, however, some disadvantages; steam used on board ships is saturated, and, therefore, a very little cooling produces condensation. From this comes the necessity of applying drain cocks to the circuit of steam, and to the cylinders of working machinery; further, the flooding by water of a compartment of the ship through which the steam circuit passes might interrupt the action of many machines. For instance, if the flooding should be in the after hold of the ship, all the machinery placed in the after end of the flooded compartment, among which is the steering gear, would inevitably become inactive.

Steam circuit must be complete; that is to say, it must have two pipes—one for sending the steam to the cylinders of the working machinery, the other for discharging the steam from these machines into a surface condenser before passing again as water into the boilers. Herein is a greater difficulty and complication than in systems with one pipe only. Another disadvantage, moreover, is the quantity of lubricating substances which from the various auxiliary steam engines find their way to the condensers and thence to the boilers, considerably impairing both the good action of the latter and their durability. Finally, in a steam system there is this other drawback—that it heats the parts through which it passes or in which it acts.

As far as the actual power from the steam system is concerned, it is made up of two factors, namely, the power resulting from the boilers and the power resulting from the steam circuit, properly so called. And we may say at once that the net result of power is not very high, because for auxiliary engines simplicity and steadiness of action are aimed at rather than special economy of steam. However, some improvements have been made of late years, and in modern vessels with high pressure steam the auxiliary engines that have to be kept repeatedly and long in action are made of the compound type with considerable economy of steam. In the compound type of engines the consumption is reduced by nearly 30 per cent. Further progress may be made in this direction. If steam for transmitting power is economical on board ships, where the distance to which power is required to reach is not very great, it is no longer so on land at greater distances, owing to the great condensation in the steam pipes.

On board ships, where the main engine is moved by steam, it finds a very suitable application, preferable to any other, for the auxiliary machinery in the engine and boiler rooms, more especially for the machines in which steadiness and continuity of action is indispensably required; and among these latter are the pumps and all machines that are an integrant part of the moving apparatus of the vessel and necessary for its action. For such apparatus steam offers every advantage, and most of the objections noted above are avoided.

Transmission and Distribution of Power by Water at High Pressure, commonly called the Hydraulic System.—This is already in actual application on war ships for the working of large guns, and in some also for the steering gear, the winches, the capstans and the windlasses. In merchant ships hydraulic apparatus is not much used. Only comparatively few make use of it for loading and discharging cargo, notwithstanding that it is so well adapted for that service. This is probably owing to the greater first outlay. The chief merits of this system are its simplicity and steadiness, serious accidents rarely occur, its management is easy, and, above all, there is a perfect control over the working of the apparatus, which can be promptly regulated at will and with precision. This precision is of course due to the liquid being incompressible.

In ships, the system in question has also the advantage, not to be found with steam, that no inconvenience arises in case any part or parts of the ship, containing hydraulic apparatus, or crossed by the hydraulic circuit, become flooded. All my readers must perceive the importance of this as regards the steering apparatus. Moreover, with the hydraulic system no radiation of heat, nor hot water leakage causing dampness or unwholesomeness, are possible; and an escape of the moving fluid, which, in the case of steam, might be attended with disastrous consequences, which would cause no mishap.

The hydraulic system requires, equally with the steam system, two sets of pipes, one to lead the water to the apparatus, the other to discharge it and lead it back to the pumps. With this difference, however, that hydraulic pipes are small in diameter, and for that reason they are easily fixed, nor have they the defects noted above which are inseparable from steam pipes.

Hydraulic apparatus is particularly adapted for great power, with slow rectilinear and limited movements, and still more suitable for those operations which it is necessary to regulate with facility, steadiness and precision, such as the working of guns and the fittings for loading them, the steering apparatus and the cargo cranes. For operations that do not require a slow movement, nor segmental or rectilinear movement, hydraulic apparatus is less suitable, the use of water being adapted to slow speeds only. In other cases it is evidently improper to use hydraulic power, because of the great loss that will ensue from the resistance in the pipes and valves and from the packing, and also because of the shocks to the apparatus at every changed direction of movement. Slow speeds require therefore high pressures. If we adopted hydraulic apparatus acting at low pressure and, consequently, with a large volume of water, large pipes would be needed to prevent an excessive loss of load. Both the apparatus and the connection would be heavy, bulky and unsuitable for ships, the working of the apparatus would by no means be easy, because of the difficulty in moderating the movement of large masses of water, and so we should only have the difficulties without having the advantages of steam apparatus acting at an equal pressure. Finally, for the due efficiency of the hydraulic system it is necessary that the pressure in the pipes be kept high and constant, which would be difficult if in the circuit there were several working machines in quick motion. It is perhaps owing to this reason that the hydraulic system has not received on board the royal navies that development which in other respects it would deserve.

As we have already stated, with this system a form of power different from that supplied by the boilers is used, and it is necessary, therefore, to know how to produce it. A pump moved by steam and giving back in mechanical power through water under pressure form the thermic power of the steam is what is universally used. In hydraulic machinery on board ships, with the usual proportion for the diameters of pipes and for the main valves, the result is not under 90 per cent. That of the generatrix pump is not so high.

So far hydraulic pumps on warships have been made with single expansion engines, but on more modern ships compound engines, far more economical, have been introduced. Hydraulic pumps are among the most powerful auxiliary machinery of the ship, and it is, therefore, only reasonable to study economy of steam, more especially if we consider that their action must be developed in action just when it is necessary to have all the power which the boilers are capable of developing.

The actual economical result of hydraulic pumps is made up of two coefficients, namely, the power resulting from the steam engine and that from the pump. The former, supposing the engine is compound, we may take to be 60 per cent. The latter can be set down at 85 per cent., and therefore, the power resulting from the pump is about 51 per cent. I disregard the loss of power in the pipe leading the steam to the hydraulic pumps because it is insignificant, these pumps being, as a rule, placed near to the boilers. The total resulting power of the hydraulic system is, therefore, equal to $0{\cdot}90$ by $0{\cdot}51 = 46$ per cent. or nearly so. By the present system the action of every machine is dependent upon that of the steam hydraulic pumps; so that, if the latter get out of order and cease working, all the hydraulic working machinery must also come to a standstill. It is owing to this that in warships whenever hydraulic gear is applied there are always two independent hydraulic pumps in action, they are both kept going so that one may fill the place of the other in case of any accident. This requirement applies not only to the hydraulic system, but to all systems in which no direct use of steam is made.

As it has been stated before, the hydraulic system cannot universally be applied for the transmission and distribution of power on board ships, because it is not suitable to move machinery, so generally used on board, in which rapid motion is wanted.

Transmission and Distribution of Power by Compressed Air.—This system in many points bears an analogy to the hydraulic, but it differs essentially in respect to the nature of the moving agent. In the hydraulic system the moving agent is an incompressible and inexpansible fluid, and, therefore, in the process of transferring the steam power to the water, the mechanical work of the plungers of the pumps (exclusive of the loss by the friction of the water in the pipes, in the passages, etc.) is integrally transmitted to the working machinery in the same form of mechanical power, without any further transformation.

In the compressed air system, on the contrary, the fluid being elastic, the thermic energy of steam acting in the engine of the pump which compresses the air is ceded to the compressed air, partly under the same form and partly under mechanical form. The first part, representing the work of compression of the air from atmospheric pressure to the pressure at which the air acts in the system, if not duly utilized, would cause a serious loss. By the same reason that the fluid is elastic, compressed air is very well adapted equally with the steam to the requirements of all kinds of machinery, viz., from slow to very quick motion; being only inferior to the hydraulic system in so far that it does not permit the regulation and control of these motions with that precision and steadiness which can be attained by the latter system. But as a compensation its merits are such as to bring it to the front for the transmission and distribution of power on board ships.

First of all the compressed air circuit is open, that is to say, it consists of the simple compressed air transmission pipe from the condensing pump to the working machinery, the air is discharged into the atmosphere after having done its work. Furthermore, the air which is thus discharged, being cold and pure, serves to ventilate and keep cool the compartments of the ship in which it is acting; these compartments under the steam system, unless they be provided with plenty of artificial ventilation, it is utterly impossible to live in, on account of the excessive heat. To this it may be added that this air, if discharged at a few pounds pressure into the foul air exhaust, will increase the fresh air circulation in the above compartments (up to 40 times) without having need of any special mechanism.

Those who are aware of the many difficulties which exist in ventilating the compartments in modern vessels will freely admit the importance of these advantages afforded by the compressed air system. This system, like the hydraulic system, presents the advantage of being a safe one in case of any damage happening in the circuit or in the working machinery, for a compressed air escape can neither injure anybody nor paralyze the whole ship, as is often the case with steam. Compressed air is also free from condensation, or at least it may be made so, and consequently there is no leakage or dropping of water to render the compartments of the ship damp, and for this reason there is no need of pipings to gather leakages. Besides, by compressed air the working machinery can continue working even though the compartment be flooded. This advantage, shared only with the hydraulic system, is especially important for the steering apparatus.

Another special advantage of the compressed air system is that by a simple arrangement of valves we can at once use steam instead of air to move the various auxiliary machines, if the compressors should fail in acting, and also in pressing cases of fire on board or of

springing a leak, when these compressors might either fail altogether or there may not be time to put them to rights. To do this it is sufficient that the discharge of air should take place into the foul air discharge pipes which are to be found in the compartments in which compressed air is acting, and in which pipes steam would produce, like compressed air, a strong current of discharged foul air.

In short, the system is simple; it does not require piping of a large diameter and it is easily put into actual practice. It could easily be applied even on board existing vessels on which all the working machinery is by steam, the work being equally well performed by compressed air. Consequently the thing in question is not that of introducing new and complicated machinery, which would require special knowledge, or be difficult and delicate to regulate, but only a different gas, more suitable than steam with the same machinery now existing on board and in the same manner.

The use of compressed air on board vessels is therefore, I believe, of very wide application, and with the exception of loading apparatus for guns, for which much simplicity and precision of movement is necessary, I hold it, in general, to be a very convenient form. I include among the latter also the turning gear for turrets or large gun training engines, in which precision of motion, owing to the great inertia of the parts in motion, cannot be obtained even by the hydraulic system. I am of opinion we ought only to exclude from this the auxiliary machinery of the main engines in which continuity of action is required.

Other less important secondary machinery may also be operated by steam, especially if they are in the engine or boiler space; but in many cases it will perhaps be better to have also these worked by compressed air. Compressed air is besides eminently well adapted to move the engines of dynamo-electric machines which are as a rule placed in closed compartments and require a cold temperature. It would also be convenient to apply compressed air to all machinery on deck where steam is liable to condensation. As in the hydraulic system, in order to insure the continued action of the machinery, it is necessary to have at least two compressing pumps, so that one of them may fill all the requirements of service in case the other one should fail. In action all the above pumps are expected to be at work. In ordinary circumstances one alone might be sufficient, owing to the fact that then only a few of the working machines are kept working at once.

Now we must say something of the economy of this system.

Until a few years ago the economic results of the existing appliances for power transmission and distribution by compressed air were little known, owing to the imperfect way in which this system was carried out. But now, thanks to Prof. Riedler's exertions, this system has been brought to such a degree of perfection as to allow of a very high economy, and which may be favorably compared with other systems. Applications, on an extensive scale, for the transmission and distribution of power by compressed air were first made in Italy by the Italian engineer, Sommeiller, for the perforation works of Mont Cenis. Then the same was again applied in Italy for piercing the St. Gothard tunnel, and in Paris and Manchester for distributing power to private houses according to Popp's system. In all these applications, in which the object is to send and to distribute power to a distance of some miles, the causes of their insufficiency lie:

1. In the imperfection of the compressors.
2. In the passive resistance in the piping which distributes the compressed air.
3. In the imperfection of the engines compressing the air.

The inefficiency of compressors was chiefly caused by the air compression being effected adiabatically, *i. e.*, without cooling the air, so that it gave out a heat which was then entirely lost in the pipe, at the end of which, where the air was to be utilized, the air was just as cold as when first entering the compressor. Thus all the difference of work between the necessary work to compress the air at a constant temperature and that necessary to compress it at a constant pressure was lost. In consequence of this, with an air pressure of six atmospheres used in those applications, the loss was about 30 per cent. Other reasons for this loss could be found in the imperfect type for the pumps; and in the first compressors Colladon used for the St. Gothard tunnel the lost power was such as to exceed the available power.

The power resulting from the compressors was first raised by cooling the pipes by cold water jackets; but a still greater success has been obtained by Professor Riedler by dividing the compression into two or more grades, and by cooling completely the air in refrigerators between the successive grades. In this manner he has succeeded in making the curve of compression nearly isothermal. Other improvements have been introduced in the pumps, and more especially in the inlet and discharge valves of compressed air, so that he has succeeded in reducing to say 24 per cent. the loss between the power indicated in the steam cylinders of the pump and the power available to be used as compressed air, cooled to the atmospheric temperature, at the beginning of the piping. Nearly 18 per cent. of this loss is due to the resistance of the machinery and 11 per cent. to the heating of the air. The power resulting from the most improved compressor is, therefore, for land appliances, 70 per cent. This result is for compressed air at six atmospheres pressure, which is more than sufficient for the wants on board. At a higher pressure the resulting power would be less favorable. But in appliances on board ships the distance to which the moving power is to be transmitted from the central station is very limited, the air has no time to get cold in the pipes, and, moreover, it is possible to prevent it from getting cold when it reaches the engines in which it must act. By doing so we utilize in the engines all the heat of compression left in the air, and the waste of available effect in the condenser is reduced to the waste of passive resistance, which is nearly 13 per cent., and to the slight loss due to leaks and so forth. To take the latter into consideration I will suppose that in compressors used on board the coefficient of power resulting from compressing pump be only 83 per cent. This would also be the power resulting from the entire compressor if it were actuated by an improved steam engine; but since, for want of space and the necessity for simplicity in marine apparatus, it is not possible to have the most economical type of engine, we will admit, as it has been done for other systems of transmission, that the engine of the compressor, compared with a perfect engine, will give only 60 per cent. of resulting power. In the present case also we leave out the waste in the steam pipes. Thus the resulting power of the entire compressor becomes $0{\cdot}83 \times 0{\cdot}60 = 49$ per cent.

The loss of available effect in the pipes of compressed air distribution due to air escapes and to resistance, using for the latter the same diameters as for steam pipes, is small and does not exceed 3 per cent., even in those portions of the pipes which are most distant from the compressor. In effect, in land appliances the loss of air pressure in the pipes, for a length of 400 ft., and at an air speed of 50 ft. per second, which is about equal to what is possible in the pipes of a ship, is not above 1 per cent., even taking into account the resistance of the waste for (discharge) trunks. Admitting that in the pipes on deck the total waste is 5 per cent., allowance is duly made for the loss due to the elbows, to radiation, etc. I will, therefore, suppose that the net economy of the piping of compressed air distribution is in the cases of ships, 0·95.

Now it remains to consider what is the economy of power of engines using compressed air. In order that a compressed air engine may give a good result of power, apart from other circumstances, it is necessary that the diagram of air expansion in its cylinders be, as much as possible, the inverted reproduction of the diagram of compression undergone by the air in the compressor cylinders. By this condition it is prescribed that the air in the engines should act expansively and with an approximate ratio of expansion little below that of the compression. But this is not enough. In appliances on land, even independently of load losses in the piping, it is not possible, without special contrivances, to reproduce in the engine the diagram of pressures obtained in the compressor. In fact the air comes into the engine as cold as if it had been compressed at perfectly constant temperature. Now, to compress the air at a constant temperature, it must be freed from heat, and then to expand it in the engine at constant temperature this heat must be restored to it, or else the air expanding adiabatically, *i. e.*, without transference of temperature, will get colder and its pressure will be less than it would be if the expansion were at constant temperature. Consequently the air in the engine will do less work than in the compressor. Besides the loss of available effect, there is also the inconvenience of the intense cold produced in the cylinders of the engine, by which the moisture of the air gets frozen and causes the passage to get obstructed by ice.

In order to prevent this serious disadvantage, in earlier compressed air engines the air was used at full pressure, without expansion, and the power resulting was indeed very low, about 40 per cent. But in modern engines expansion is used, and to increase the effect of it the air is heated before being admitted to the engine, and thus the evils due to freezing or to the condensing of dampness existing in the air are avoided. By the heating of the air combined with the injection of water, it is moreover possible to so increase the resulting power as to bring the work in the engine higher than the work in the compressor. In the Popp appliance in Paris, improved by Professor Riedler, the air is heated with small stoves, extremely simple, in which the heat is turned to such a great use that one one-fourth pound of coal per horse per hour is enough to double the result of power.

This is owing to the fact that the heat supplied to the air is nearly five times more efficaciously used than if it were employed in producing steam.

Water existing in or injected into the air while passing through the stove causes the air to be saturated with steam, which, getting condensed during expansion, transfers latent heat to the air. But the expediency of using injected water is more than anything else of a practical nature as forming a very efficient lubricant for the pistons. By applying air heating at 150° Centigrade temperature (302° Fahrenheit) to an old Farcot engine of 80 horse power, used as a compressed air engine and which was worked at first by steam, an efficiency of 90 per cent. was obtained; that is to say, in the Farcot engine compressed air gave out 90 per cent. of the theoretical power.

Better results might be obtained by modern compressed air engines of the compound system, in which the heating of the air is effected in two stages; but the above example may be sufficient to show that even with imperfect steam engines, with single cylinders, used as compressed air engines, a good result of power can be got.

It may be argued against the foregoing that although on land the economy is increased by artificially heating the air before being admitted into the engine, this cannot be done on board vessels except in a way which would deprive the system of all its merits. On board ships, however, it is possible to produce hot air in the compressors, and to transmit it equally hot into the engines; thus the loss of heat in the compressors used on land and the necessary heating of the same before using it in the engines are prevented. By regulating the compression so that the compressed air temperature is say 150° Centigrade (302° Fahrenheit), it is possible, as it has previously been observed, to get from marine engines a net result of compressed air power of 90 per cent. With this temperature in the admission, the air may be discharged from the engines cold, a few degrees above the freezing point, provided it acts with sufficient expansion. In many auxiliary marine engines this is impossible, but this is no inconvenience, because, as I have already stated for auxiliary engines, in the compartments of a ship the air must be discharged from the engines into the foul air discharge pumps, so that these engines might be worked by steam when compressed air fails. Therefore the net result from the compressed air system of transmission and distribution will be $0{\cdot}498 \times 0{\cdot}95 \times 0{\cdot}90 = 0{\cdot}424$, say 42 per cent., which (result) is not much below the result of power from the hydraulic system.

Transmission of Power by Electricity.—This is a very valuable system, on account of its adaptability for transmitting power to a great distance, for which other means would be unfitted, and also on account of the simplicity and facility with which power can be distributed to the various machines, whatever be their number, and wherever they may be placed or disposed. Besides, so important are the discoveries continually being made in electricity, and so rapid is the progress in its application, that we may think that, in the not distant future, electricity will be the main agent in the service of human activity. But it is not now my task to bring forward this train of thoughts, nor even to deal with the transmission and distribution of power in all its aspects, but only to treat of it in respect to the limited and special case of ships, and in the actual and present state of our knowledge. Even in the present state of development of electric appliances it is possible to execute by electricity the greater part of the functions on board ship which are now performed by steam, by compressed water, etc. In truth, by compound dynamo machines well regulated to supply variable electric currents with a constant potential, and employing also a compound motor placed derivatively on the main circuit, the working machinery can even now be moved at a constant velocity, whatever be the resistance to be overcome, and at the will of the manipulator, without the action of these motors influencing that of the others or changing the movement of the generator. And this essential condition becomes so much easier of attainment on board ships, where, the circuits being short, they can be arranged with very little resistance. With proper contrivances the velocity of the working machinery can be also varied, although not so very extensively as by other systems of transmission. In altering the normal velocity of the motors there is a loss of available effect, but this loss is not of great importance, since the motors, which are to be kept continually moving for a length of time, act generally at their normal velocity, which it is rarely necessary to alter, so much the more in the present case in which the motors preserve automatically this velocity, even if the resistance to be overcome should change. The fixing of the power transmission circuits offers but little difficulty with electric wires, which can be easily bent as desired. They are easily passed through anywhere, and easily joined again in case they should break. By electric motors there are no radiations of heat, nor the hot water leakage to make the compartments either too hot or too damp, and the very simple working of a commutator is sufficient to set up, to accelerate, to slacken, or stop the movement of the motor at will.

Electricity, therefore, in its present conditions of development, fulfills the principal requirements necessary for a system of power transmission and distribution; it may, moreover, be said that it exhibits certain advantages which other forms of power cannot afford, and for which in many cases it is preferable. But, on the other side, it has features of its own which limit the application on board ships. A special condition in dynamo-electric machinery and electric motors requires that the peripheric velocity of the armature should be high; consequently, in the case of machines and motors whose dimensions are to be comparatively small, their revolutions must be very great, and all machinery on board ships is made as small as possible for the saving of space and weight. This does not create any difficulty for dynamos, but for motors it makes it absolutely necessary to interpose gearing, or other means for reducing the speed between them and the working machinery, if the latter works at a lower speed. It follows that electro-motors are more particularly adapted for the apparatus requiring rapid motion and are, perhaps, unsuitable for those with slow movement, when the intervening gearing required for transforming the movement becomes out of place or embarrassing; because gearing, besides complicating the apparatus, causes also, as a rule, a loss of power and sometimes a considerable loss to power. Electric apparatus is besides distinguished by delicacy of construction and the subtle nature of the electricity itself. How greatly improved soever electric apparatus may now be, yet it cannot be contradicted that there is still uncertainty as to the steadiness of action. Variations may arise from the slightest causes, not always easy to detect at once nor easy to remove.

As an instance, a contact between the two branches of the main circuit may paralyze all the machinery, and besides produce irreparable damages in the generators. It is not easy, as a rule, to find out either the cause or the cure of even slight mishaps. This observation will be readily admitted by those who have had some experience in the electric lighting service on board vessels, where not unfrequently considerable time is needed to find out the cause of inaction of circuits or of the dynamo generator. If a steam pipe breaks, if an ordinary machine gets out of order, it is not difficult to spot the place, even for those who have but a slight experience, and to see at once the best way to repair it; but when any disarrangement happens in the interior of an electric apparatus or in any point of circuits' system, it needs the experienced mind of a skilled electrician to inquire into the causes, and all his ability to set things in order again. These defects impair, at least for the present, the advisableness of applying electricity to move apparatus in which steadiness and continuity of action is necessary, or that cannot be readily functioned by other means when electricity fails. This applies especially to the auxiliary machines which are integral parts of the main engines of the ships, and also to the steering gear.

In France electric motors have very successfully been applied for elevating and working guns, but only small guns which could have been moved by hand, and it is still doubtful whether electricity is suitable for larger guns. On the French ironclad Jaureguiberry, now in course of construction, in the yards of the Societe des Forges et Chantiers de la Mediterranée, the turrets for guns 15, 27, and 30 centimeters each, which can also be worked by hand, will be supplied with electric motors. It is said, however, that electricity will be used on board this war ship for other services as well. But electro-motors are very well adapted for ventilating engines which revolve rapidly, and no serious harm will ensue if they cease to act.

As in the case of the transmission of power by water or by compressed air, so in that by electricity, it is necessary, in order to secure as much as possible the continuance of action of the working machinery, to have at least two dynamo generators, and both kept moving together when the ship is in action.

With regard to freedom from mischief done by an inflow of water, electricity is worse than either compressed air or water, for the reason that all electric

motors in the flooded compartments would necessarily cease from acting. By the same reason electro-motors are not very suitable for deck apparatus which are exposed to rain or to heavy seas. Finally, electro-motors are not very well adapted for machinery designed to execute the working, for instance, of the rudder, of the anchors, etc., in which the resistence to be overcome might suddenly change and be beyond the power of the motor, since in such cases the current might increase too much and cause mischief. I am inclined, therefore, to think that, upon the whole, the area of electric application on board vessels is not so extensive as it might at first sight appear, and that great improvements must be made before electricity supersedes those other means which are now used for the transmission and distribution of power. I do not mean to say that these improvements will never be attained. On the contrary, in all probability, if not certainty, this will be done, and perhaps the day will come when even the main marine engines will become electro-motors; I mean when we shall be able to store up on board ships electric power in the same way we do now store up coals, or rather, when we shall succeed in transforming directly into electricity the power contained in coal.

All authors agree that for short distances the result of power of this system is very high. If we suppose the actual efficiency of the dynamo engine is 0·60, the entire efficiency of the electric system of power transmission and distribution is $0{\cdot}60 \times 0{\cdot}75 = 0{\cdot}45$, say 45 per cent., which little differs from the result given by the other indirect systems, viz., by compressed air or by hydraulic apparatus.

Comparison of Weight, Cost, Volume, and Working Expenses of Auxiliary Machinery by the Various Systems of Transmission and Distribution on Board Vessels.—Before summing up the examination of the different systems for the transmission and distribution of power, before forming a final judgment as to their relative efficiency for the service of auxiliary machinery on board ships, we must make a comparison between these systems from the point of view of the weight, cost, and volume of the apparatus and of the working cost of the same, in case one of them were applied in general to the exclusion of others. To look closely into this subject I will direct the attention in particular to the instance of a first-class man-of-war, of which I have already indicated the number and power of its various machines, and taking the maximum collective power of the auxiliary machinery when in motion and when in action to be 1,200 horses. I will further suppose that the circuits of transmission and distribution have the same development in every case, and that their weight is in proportion to the unit of weight per foot of the principal branches by which they are composed; and, finally, to establish approximate figures of comparison, I will suppose in each case the weight of the entire circuit, branch lines included, to be equal to that of its main branches over a length of 650 ft., and with the size carried to the end equal to the size at the origin or beginning of the circuit.

Direct Steam System.—In this system we have only to consider the steam circuit and the steam engines of the different working machinery. To lead the necessary steam for a power of 1,200 horses, from 75 lb. to 90 lb. pressure, such as is generally used on board modern ships, steam pipes are required of about 7 in. in diameter, with an average weight of about 20 lb. per foot, and thus the total weight of the steam circuit will be $2 \times 650 \times 20$ lb. = 26,000 lb. or 11½ tons. The weight of auxiliary engines in modern ships varies from 44 lb. to 110 lb. per indicated horse power, according to the type, to their revolutions, and to the manner in which they are applied to the apparatus they have set in motion. Taking the intermediate figure of 88 lb., in the instance of the ship we have undertaken to examine of nearly 2,400 horse power in its auxiliary apparatus, its engines will be 96 tons total weight. Calculating the pipes at £200 per ton, and the engines at £120 per ton, including the fitting, the cost for steam system will amount to £2,300 for the former and to £11,500 for the latter. With regard to the space taken by the pipes and engines, I will fix the estimate on the basis of average density (weight divided per circumscribed volume). It may be admitted that in marine apparatus the average density of tubes is 0·8 and that of engines is 1·2.

This being so, we have for steam system:

Steam.	Circuits.	Machinery to Transform Power.	Motors of the Apparatus.	Total.
Weight	12 tons.	.....	96 tons	108 tons
Cost	2,300*l.*	.....	11,500*l.*	13,800*l.*
Volume in cubic meters of 35 cubic feet each	15	.....	80	95

Hydraulic System.—In this case there ought to be, for the main branches of the circuit, pipes of about 4½ in. internal diameter, the weight being on an average between the admission and discharge pipes about 20 lb. per foot, and, consequently, according to the hypothesis previously made, the weight of hydraulic circuits will be 11½ tons. But hydraulic engines are much heavier than steam, their weight varying from 220 lb. to 660 lb. per horse power, according as their action is rather slow or very slow. Adopting the lesser figure, which is, perhaps, the nearer approximation, we have, for hydraulic motors, a weight of 240 tons. It is necessary to add to this weight that of the hydraulic pumps which supply the water. I will suppose there are on board five pumps, four being sufficient for the service, and the fifth one should be kept as a subsidiary pump in case any of the former should fail. Each one of these pumps must have an indicated power of say 400 horses, and weigh nearly 30 tons. Therefore, the weight of the five pumps would be 150 tons. To this we must finally add the weight of the water and the weight of suction tanks. The total weight of both together would be about 40 tons. The density or weight of hydraulic circuits and machinery, without water, is greater than that of circuits and machinery by steam, and we may admit on an average the following figures: Density of circuits = 2·5, density of machinery = 2, density of the tanks with the water = 1. This being so, we have:

Hydraulic.	Water and Tanks.	Circuits.	Machinery Transforming the Power	Motors of Apparatus.	Total.
Weight	40 tons	12 tons	150 tons	240 tons	442 tons
Cost	400*l.*	2,400*l.*	18,000*l.*	28,000*l.*	49,800*l.*
Volume in cubic meters of 35 cubic feet each	40	4·8	125	120	289·8

Compressed Air System.—In this system the circuit is open, that is to say, it is formed by the single branch which leads compressed air to the working machinery, and, consequently, neither discharge pipes nor return pipes are needed, as in other systems. For admitting the air the same pipes can be used as those required for steam, because the air can be used at the same pressure as that of steam. The weight of the pipes would be about 29 lb. per foot, and, since its development is the half of that in the preceding cases, the weight of compressed circuit will be $29 \times 650 =$ 18,850 lb., or say 8 tons.

The engines remain the same as in the system by steam, and of which we know already the weight. To the weight just now indicated it is necessary to add the weight of the air compressors. Equally in this case I will take five compressors of 400 horse power each. Their weight is nearly 220 lb. kilogrammes per horse, or rather, their total weight is 200 tons. We shall, therefore, have for the compressed air system, adopting also the same coefficients:

Compressed Air.	Circuits.	Machinery Transforming Power.	Apparatus Engines.	Total.
Weight	8 tons	200 tons	96 tons	304 tons
Cost	16,000*l.*	24,000*l.*	11,520*l.*	37,120*l.*
Volume in cubic meters of 35 cubic feet each	10	166	80	256

Electric System.—In the actual applications on board ships a very low potential of only 65 volts is used, which, for electric lighting service on ships, seems suitable, but I think this would no longer be adequate in the present case of a general system of transmission and distribution, on account of the enormous current which it would be necessary to transmit into the circuit. In effect, admitting an efficiency of 90 per cent. resulting from the dynamo-electric generators and the electric motors, the electric power at the origin of the circuit should be of $\frac{1{,}200}{0{\cdot}9} = 1{,}300$ electric horses, to form which, with a potential of 65 volts, would require a current of 15,000 amperes. And since the circuits would be covered and could not admit a current above 2 amperes per square millimeter of section, it follows that the two branches of the circuit at their origin must be composed each one of a bundle of 75 copper wires of a square centimeter section each (38 in. each). The weight of the entire circuit would be nearly double that for steam or hydraulic circuits. But there is also this to be said, it would not answer, owing to the difficulties coming in the way, to apply on board ships dynamo-electric engines acting with more than 1,000 amperes, and, for the same reason, wishing to get all the necessary power with an engine of 1,000 amperes, it would require a battery of 15 dynamo-electric machines. With so many machines at work, the probability of their getting easily out of order would be great indeed; and, besides, that regularity of action which is so much needed could hardly be expected from them.

It is, therefore, necessary to have the dynamo generators reduced to a much smaller number, which could be done by duly raising their potential. Thus, by bringing the potential to 200 volts, the necessary dynamos would be reduced to five, a figure which may be admitted. It would also be necessary to have a spare dynamo in case any of those in actual service might get out of order.

For the electric lighting service requiring a lower potential, it would, perhaps, be convenient to leave on board the special engines and special circuits which exist at present. I do not, however, consider this now, but simply suppose that the electric lighting service is performed by the large dynamos for power transmission. Adopting this solution, the weight of the circuit would be reduced to a third of the preceding, and be, therefore, nearly two-thirds of the weight required for the steam or hydraulic system. The six dynamos ought to be worked by steam engines, each of 320 indicated horse power. Calculating the entire weight of the dynamos and engines at the rate of 2 cwt. per horse, a rather low figure, the total weight will be 192 tons.

The weight of electric motors varies from 1 cwt. to 2 cwt. per horse power, according to their type, the speed of their acting, etc. Supposing it may be possible to adopt the lightest motors, the weight of the motors which are necessary to move all the auxiliary machines on board requiring the complete power of 2,400 horses will be of 120 tons. Applying the coefficients previously established in the case of steam system with regard to the cost of these apparatus and the volume of same, which are pretty well adapted to the present case also, we have:

Electricity.	Circuits.	Machines Transforming Power.	Motors of Apparatus.	Total.
Weight	9·6 tons	192 tons	120 tons	321·6 tons
Cost	1,920*l.*	23,040*l.*	14 400*l.*	39,360*l.*
Volume in cubic meters of 35 cubic feet each.	12	160	100	272

Comparing the results of the above tables, we observe that whether for the weight, the cost, or the space taken, direct transmission by steam stands first. The electric system and the compressed air system come next; while the hydraulic system, which requires greater weight and cost, comes last. Even in so far as actual working costs are concerned, the direct system by steam must necessarily be the first. After that, admitting that the sinking fund expenditure is in proportion to the cost, and the result of the three indirect systems being nearly the same, the most suitable system would be the electric one; but it is also well to notice that the cost of the latter is nearly the same as that of the compressed air system, and because electric apparatus is much more delicate than compressed air, it may well be that, owing to the heavier outlay for the management of the former, the compressed air system is the more advantageous.

Conclusion.—From the above statements I think we may draw the following conclusions:

1. The direct steam system is, because of its efficiency, regularity, and steadiness of action, economy in weight, space, and cost, the most suitable.

Consequently, in the majority of cases it is the more preferable of systems, and it is, in fact, preferred. But, admitting that for special reasons it may be found expedient, for the moving of auxiliary machinery, to make use of one of the indirect systems of transmission, steam being the first source of power, and the efficiency of the same being truly reliable, steam power may still be the proper one to use for all machinery forming an integral part of the apparatus of the ship and necessary for its action. This machinery consists of the circulating, the feed, and the air pumps, the starting gear, and, generally speaking, all machinery in the engine and boiler rooms.

2. The water pressure system is not suitable for general use, but it is very well adapted for the working of large guns. If it should be used for the latter, it may also be successfully applied to the steering apparatus.

3. The compressed air system may be very advantageously applied to all the auxiliary machinery of the ship, excepting only those machines, which are an integral part of the main engines, owing to the reasons hereinbefore stated, and excepting the working of large guns, for which the hydraulic system is preferable. But for ammunition lifts and turning gears of turrets and platforms compressed air could successfully be used.

4. The electric system is not the proper one to use generally for the transmission and distribution of power, but it might answer for the working of middle size and smaller guns, and for moving machinery which revolves rapidly, such as for instance the ventilators.

But in case compressed air should be used on board ships as a general means of power transmission and distribution, it would be better to use it, even for the ventilators (especially if they are exposed to coal dust), rather than to use electricity.

Applying the above reflections to the case already mentioned of a first-class man-of-war, the proportions given in the annexed table would be suitable for the different systems of auxiliary machinery.

According to this distribution, the total collective power of machinery worked by compressed air would amount to nearly 1,500 horses, but, taking into account only the machines which in action must work at the same time, it would be sufficient to have a disposable compressed air power of 800 horses, which would be given by four main compressed air pumps of 250 horses each. In addition to this there should be an auxiliary compressed air pump, also of 250 horses, in case one of the main pumps should get out of order. Thus the weight of machinery on board, owing to the addition of compressed air pumps, would be augmented by say 125 tons.

Apportionment of the Various Systems on Board a First-Class Man-of-War.

	Main Engines.	Auxiliary Engines.	Hydraulic Motors.	Air Motors.	Electric Machinery.
Main engines	19,300	19,300			
Circulating pumps	240	240			
Main feed pumps	160	160			
Auxiliary pumps	240	240			
Auxiliary condensing pumps	40	40			
Bilge pumps	120	120			
Turning gear for main engines	50	50			
Starting gear	50	50			
Fire engines	60	..	..	60	
Exhaust pumps	140	..	..	140	
Compressed air pumps for torpedo service	60	..	..	60	
Hydraulic pumps	160	..	..	160	
Steering gear	200	..	..	200	
Capstan	160	..	..	160	
Warping capstans	100	..	..	100	
Dynamo engines	130	..	..	130	
Forced draught engines	240	..	..	240	
Ventilating engines	..				
Ash hoists	30	..	..	30	
Workshop engine	10	..	..	10	
Gun training engines	160	..	..	160	
Ammunition lifts	100	..	..	100	
Compressed air pumps for power	1,250	1,250			
Hydraulic gear for large guns	..	.	120		
Electric light	..	..	..	..	100
Electric power for working rapid-firing guns	..	..	..	..	29
Total	—	21,650	120	1,550	129

H. M. CRUISERS PIQUE, RAINBOW, AND RETRIBUTION.

MESSRS. PALMER'S Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne, have delivered to the Admiralty the three cruisers which they were intrusted to build under the Naval Defense Act. The vessels are second-class cruisers of the following leading dimensions and particulars:

Length between perpendiculars	300 ft.
Breadth, extreme	43 ft. 8 in.
Depth moulded	22 " 9 "
Displacement on a mean draught of 17 ft. 6 in.	3,600 tons.
Indicated horse power	9,000 tons.
Speed	19¾ knots.

Each vessel, as will be seen from our engraving, from a photograph of the Retribution, has two funnels and two pole masts, with a light fore and aft rig. The hull throughout is built of steel, and the bottom of the ship is sheathed with teak 3½ in. in thickness to 2 ft. above the water line. The stern, sternpost, rudder, and shaft brackets are of phosphor bronze, manufactured by Messrs. Steven & Struthers, of Glasgow. There is a steel protective deck which extends the whole length of the vessel. The transverse section of this deck is in the form of a flat arch, the crown of which rises 1 ft. above the water line at the center of the vessel, and slopes down toward the sides to a point 4 ft. below the load line. The thickness is 2 in. on the sloping part and 1 in. on the crown. The engines and boilers, magazines, steering gear, etc., and other "vitals" of the ship are placed under the protective deck. Vertical engines are adopted, and, in order to insure protection to the cylinders, which project above the protective deck, a belt of armor of solid steel 5 in. in thickness with 7 in. of teak backing is fitted round the engine hatchways between the protective and upper decks. Each vessel is divided into a large number of water-tight compartments, and has a double bottom the full extent of the engine and boiler space, the continuity of which is carried forward and aft by the water-tight flats forming the magazines, shell rooms, and store rooms. The bunkers are placed alongside the engines and boilers, and extend to the upper deck. There are two separate engine and boiler rooms. Above the protective deck aft are the cabins for the ship's officers, the part amidships being occupied by coal bunkers, engineers' workshops, washplaces, etc., while the forward part is entirely devoted to the crew. Under the poop are placed the cabins of the commander and principal officers, ward rooms, etc., the forecastle being taken up by the crew. The armament of each vessel consists of two 6 in. breechloading guns, one mounted on the poop and other on the forecastle, both placed on the middle line of the ship; six 4·7 in. quick firing guns, three on each broadside; eight 6 pounder quick firing guns, one 3 pounder gun, and four 5 barrel Nordenfelt guns, mounted on suitable stations along the sides of the vessel; a 9 pounder gun for boat and field purposes is also secured on deck. In addition to this, four torpedo tubes are fitted, one forward, one aft, and one on each broadside. For controlling the ship in action a conning tower of steel 3 in. thick is fitted on the aft end of forecastle, inside of which the various telegraph instruments, steering wheel, voicepipes, etc., are placed. As regards the pumping arrangements, an elaborate system of piping is fitted, extending to every department, while the fire service and sanitary arrangements are on the same elaborate scale. A complete installation of electric light is also fitted, including three powerful search lights. The crew number 250 hands all told.

The engines are vertical, of triple expansion type, and drive twin screws. They were designed and constructed by the Palmer's Company under the direction of Mr. J. W. Reed, manager of the engine works. Each set of engines is placed in a separate water-tight compartment, these being divided by a middle line bulkhead. The diameters of the cylinders are 33¼ in., 49 in., and 74 in., all with 39 in. stroke of piston. They are placed with the high pressure cylinder forward, the intermediate pressure in the middle, and the low pressure aft. The valve chests are placed on the forward sides of the high pressure and intermediate cylinders and on the after side of the low pressure cylinders, a piston valve being fitted to the high pressure, while the intermediate pressure and low pressure have double-ported flat slide valves, fitted with Church's relief rings in the back. The cylinders are quite independent castings, but connected by bar stays and copper pipes. The breeches standards are also connected near their tops by struts. The liners of the high pressure and intermediate cylinders are of steel, while that of the low pressure is cast iron. The pistons, together with the cylinder and valve chest covers, are all of cast steel. This latter material is largely used in the framework of the engines. The back standards are of the split type of box section and of cast steel, with the piston rod guides attached. The bed plate for each set is in three independent pieces, each cylinder having its own bed plate. These are of box form and of cast steel, and both bedplates and standards are of a very substantial character. Each cylinder is supported at the front by two turned columns of forged steel, an additional column being placed under the low pressure valve chest.

A diagonal stay runs from the bottom of each front column up to the underside of the cylinders at the back, and the engines are further stiffened by an athwartship stay being carried from each cylinder top to a horizontal fore-and-aft girder formed on the middle line bulkhead. This makes an unusually stiff framework, and the intention of the designers was fully realized, for on the full power trials, even when running 145 revolutions, there was not the slightest vibration even at the tops of the cylinders. The crank shaft is of steel, and in two pieces, with the cranks placed at 120 deg. apart. Both shaft and pins are hollow, the diameter of the shaft being 12¾ in. The piston and connecting rods, together with most of the gear, are of steel.

The valves are driven by ordinary link motion, with the reversing shaft placed along the back of the engines. The reversing engine has two cylinders, and is snugly placed on the front of the intermediate cylinder. The reversing gear is of the ordinary all-round worm and wheel type. The handwheel in front may be put out of gear when not required. The various handles and wheels are grouped together conveniently at the front. There is one single-acting air pump placed at the back of each low-pressure engine, driven by levers from low-pressure crosshead. The condenser is of cylindrical form, of cast gun metal, and placed at the after end of the engines.

The diameter of the body is 6 ft. 6 in. and the length 8 ft. The total cooling surface for both condensers is 10,040 square feet, with tubes ⅝ in. in external diameter. The circulating water for each condenser is supplied by a 14 in. Tangye centrifugal pump. There is a cross connection between these two engine rooms, so that one pump may supply both condensers in case of accident to the other. Each pump is capable of discharging 750 tons of water per hour from the bilges. The main feed pumps are of the Weir's duplex type, one pair being placed in each engine room. The speed of the pump is controlled by a float in the feed tank. A double cylinder pump of Admiralty pattern is placed in each engine room for fire and bilge purposes. In each engine room there are also a Normandy's evaporator and condenser, air-compressing engines, and reservoirs, by Belliss, and electric light engine and dynamo by Willans & Robinson. A separate auxiliary condenser, provided with its own air and circulating pumps, is fitted in each engine room for condensing the steam used by all the auxiliary engines throughout the ship. The combined surface of the two condensers is 1,000 square feet. The positions of the various auxiliary engines have been carefully chosen, and the general arrangement of these and the main engines is such that there is unusually ample room to get easily and comfortably about.

The propeller shafting is of steel throughout, and hollow, the diameters being 12¾ in. and 14½ in. The propellers are of Admiralty gun metal, with three blades on each. They are about 13 ft. in diameter and 17 ft. 6 in. pitch.

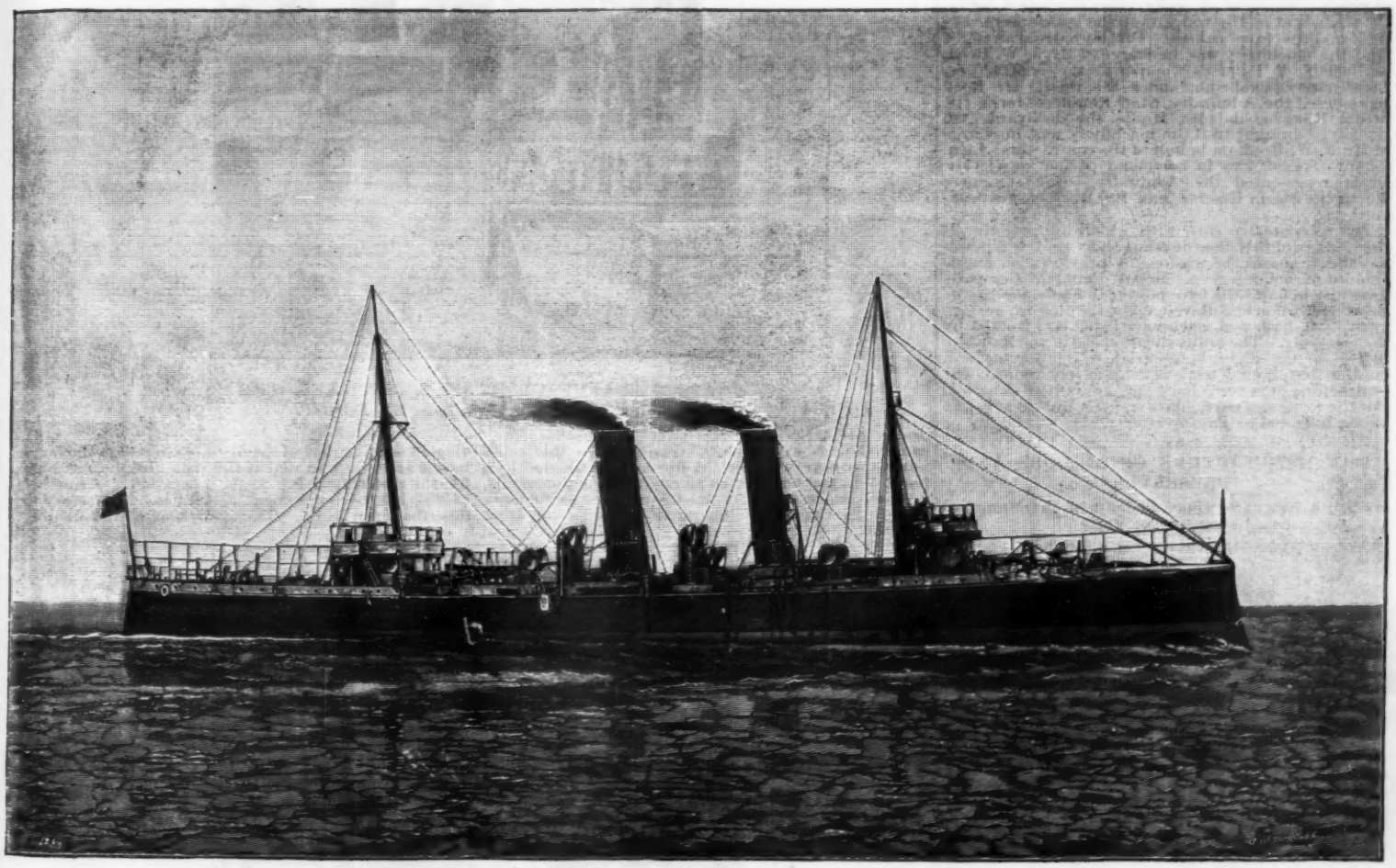
There are five return tube boilers, occupying two separate water-tight compartments. Three of the boilers are double-ended, 13 ft. in diameter by 18 ft. 6 in. long, and two are single-ended, 13 ft. in diameter by 9 ft. 6 in. long, the working pressure in all cases being 155 lb. per square inch. There are in all twenty-four corrugated furnaces, each having a separate combustion chamber. The total heating surface is 15,704 square feet, and the total fire grate surface 588 square feet.

The boilers are arranged for working under forced draught on the closed stokehold system, the air being supplied by eight double-breasted fans, made by Messrs. Paul & Co., Dumbarton. In the boiler rooms there are placed for auxiliary purposes three double-cylinder feed pumps of Admiralty pattern, one of them being especially for one of the single-ended boilers, which is intended to be used for auxiliary purposes when in harbor. Provision is made in the double bottom under the boilers for the storage of a large supply of fresh water, and connections are made from the auxiliary feed pumps to these tanks. The steam from the after boilers and from the forward boilers is led to the engine rooms by two independent lines of pipes, so that in the event of one of the boiler rooms being flooded, or its steam pipes damaged, the steam can be taken from the remaining boiler room to both sets of engines. The main steam pipes are lapped with copper wire as an additional security. In addition to the various engines already mentioned, there are ash hoists, drain tank engines, steering engines and capstan engines. A workshop is also fitted up with several machines, and a special engine to drive them.

The builders undertook to develop 7,000 indicated horse power, with an air pressure in the stokehold not more than ½ in. for eight consecutive hours, and 9,000 indicated horse power with not more than 1¼ in. for four consecutive hours. All of the vessels have been successfully tried. The trials were made off Plymouth.

The Pique went on her trials on January 27 and 30 of this year, the result of the eight hours' trial showing 7,515 indicated horse power with 0·28 in. air pressure, and on the four hours' trial 9,258 indicated horse power with 1·05 in. air pressure, the results in both instances being considerably better than required by contract, and the working of the machinery and boilers very satisfactory.

The Rainbow went on her trials on May 13 and 18, 1892. On the eight hours' trial 7,879 indicated horse power was developed with 0·32 in. of air, and on the four hours' trial 9,741 indicated horse power with 0·69 in. air pressure. In the eight hours' trials of both vessels, even with the low air pressure, it was frequently necessary to close the ash pit dampers to check the excessive generation of steam, the fans being run as slowly as possible without stopping.



THE NEW BRITISH WAR SHIP RETRIBUTION.

H. M. S. Retribution, the third and last cruiser, underwent her trials on September 16 and 19. On the former day she went outside Plymouth breakwater and had a most successful eight hours' trial, everything working in a most satisfactory manner. The contract power was exceeded by 645 indicated horse power, although the air pressure was only one-half that allowed by contract. The mean results were:

Steam in boilers	144 lb.
" engine room	141 "
Air pressure	½ in.
Revolutions	128·8
Vacuum	28·1
Collective indicated horse power	7,645

On the 19th of October she went out again for her four hours' trial under forced draught, and this trial also was marked with the same success as attended the natural draught trial. There was nothing to be gained by exceeding the contract power to any extent, and no attempt was made to show a high indicated horse power, as the Rainbow had shown clearly what could be done. The object in the present case was only to obtain the contract power with a reasonable margin. The result showed that the contract power was exceeded by 367 with an air pressure of less than half that allowed by contract. The mean results were:

Steam in boilers	148 lb.
" engine room	145 "
Air pressure	0·61
Revolutions	138·8
Vacuum	28
Collective indicated horse power	9,367

Throughout both the trials the engines worked remarkably well, and the boilers gave a very free supply of steam. No signs of leaky tubes developed during the trials, and at the conclusion the boilers were very tight and free from leakage. On the natural draught trial the machinery was in charge of Mr. J. W. Reed, on behalf of Palmer's Company, the contractors; Lieutenant Oswald commanded the vessel; Mr. Rock represented the Admiralty, Staff Engineer Morris the Steam Reserve, and Mr. Hobbs the dockyard. On the forced draught trial the machinery was in charge of Mr. J. W. Reed, on behalf of the contractors; Lieutenant Oswald was in command of the vessel; Mr. Oram represented the Admiralty, Staff Engineer Morris the Steam Reserve, and Mr. Marrack the dockyard.

The comparative ease with which the majority of the cruisers of this class develop their contract power has clearly shown the wisdom of providing an ample amount of boiler power. Messrs. Palmer & Company have also in hand the two powerful first-class battleships Resolution and Revenge, for the English government, both hulls and machinery being constructed by the company. The approximate speed of the Rainbow by log, on the eight hours' trial, was 19·4 knots, and on the four hours' trial, 20·2 knots per hour. The contractors, however, have no guarantee of speed. For the foregoing particulars and for our illustration we are indebted to *Engineering*.

THE MANUFACTURE OF LIQUORS AND PRESERVES.*

By J. DE BREVANS, Chief Chemist of the Municipal Laboratory of Paris.

PART II.—ARTIFICIAL LIQUORS.

CHAPTER I.

The Plant of the Distiller.

THE laboratory of the *liquoriste* or distiller should be of sufficient size to enable him to carry on his work

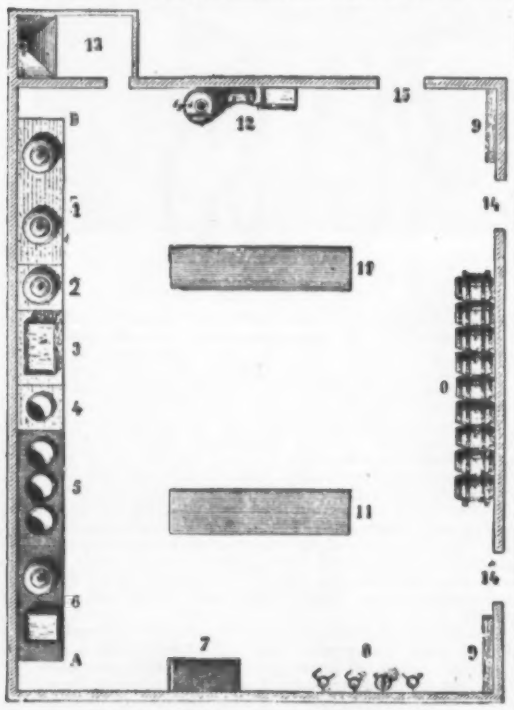


FIG. 21.—PLAN OF A DISTILLERY.

1. Steam stills. 2. Stills for open fires. 3. Common condenser. 4. Heating basin (open fire). 5. Basins heated with a water bath. 6. Independent still. 7. Digester for making preserves. 8. Filters and digesters. 9. Closets. 10. Casks. 11. Work tables. 12. Steam generator. 13. Private laboratory.

with facility. The walls should be well built and of sufficient height to prevent the flames from burning the ceiling in case of fire. The laboratory should be well ventilated, lighted from above and paved with brick, stone or gravel. An abundant supply of water should be at hand. The chimney must be large and well constructed and should terminate in a hood, under this are placed the stills (Fig. 21, A, B). The chemist should have a small private laboratory (13) where he can make his experiments. The plant in this small laboratory is very simple: A furnace surmounted by a hood, some gas burners, an alembic, a case of reagents, a good balance, a case for fine instruments, and a work table. In the plan illustrated herewith the store rooms ought to be as far away as possible, on the same floor as the laboratory. It should not be damp and the temperature should be maintained between 12 and 15° (C.) The floor is generally graveled or paved with an asphalt.

The cellars must be well ventilated, have a northern exposure and a depth of 5 or 6 meters.

Figs. 22 and 23 represent a large distillery at Saint Denis, for the manufacture of liquors. In Fig. 22 a battery of stills of medium size are shown, the worms having a condensing tank in common. Fig. 23 is a

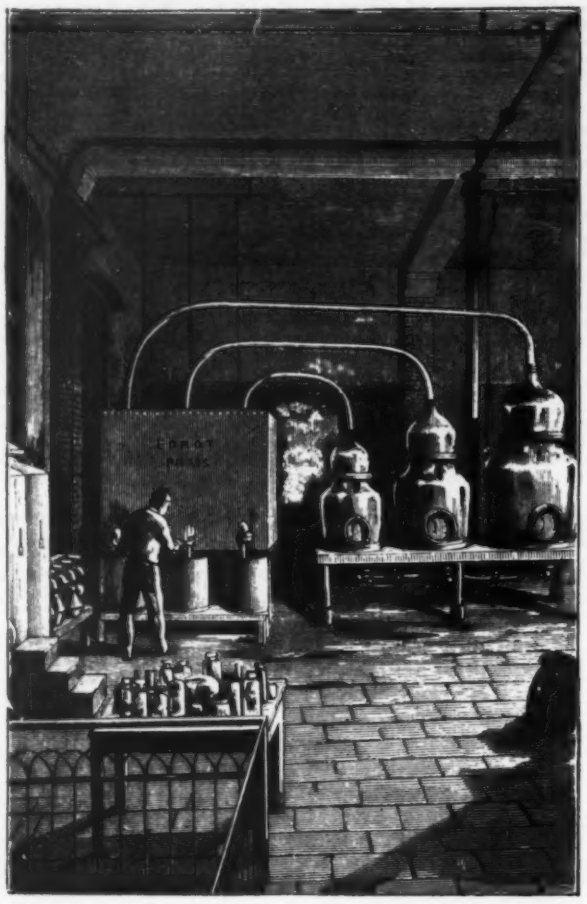


FIG. 22.—MANUFACTORY OF A DISTILLER—THE STILLS—INSTALLATION BY EGROT.

view in another part of the distillery in which the large basins are set up, as well as the stills and the receivers for the raw materials. As the operation of a number of stills has been described, it will not be necessary to describe them again. The operations of the distiller require a large assortment of basins of copper, both tinned and untinned, steam-heated basins and basins heated by an open fire (Figs. 24, 25, 26, 27), skimmers, spatulas, an assortment of alcoholometers and hydrometers, mortars, balances, etc.

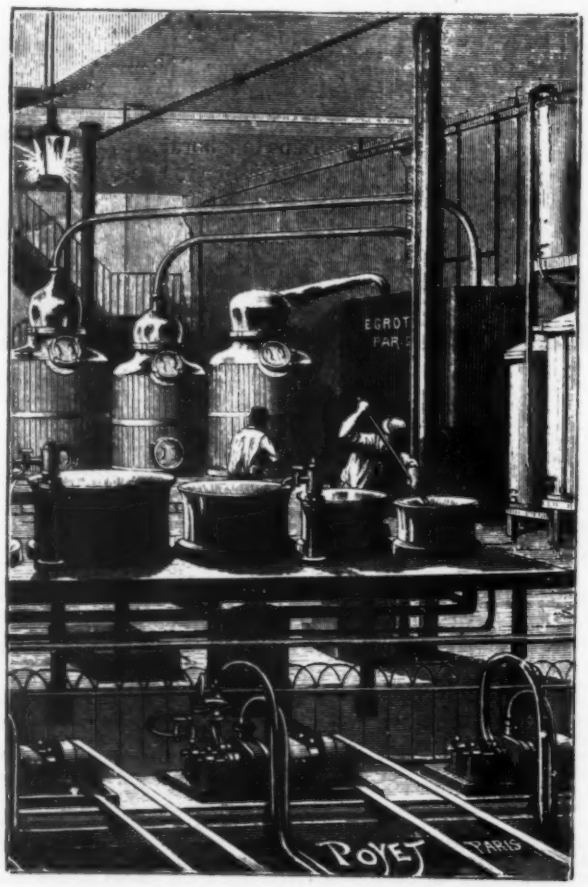


FIG. 23.—MANUFACTORY OF A DISTILLER.

* Continued from page 14127, SUPPLEMENT No. 884.

The filtration of raw materials and the finished products requires the use of bone black filters. Fig. 28 represents one of the great tinned funnels terminated in a cock. The distiller must have at his disposal a series of siphons of different sizes in glass or metal. Fig. 29 represents a siphon of large size, and it is very convenient for transferring alcohol. The reservoirs or holders of raw materials and finished products are made of tinned copper (Fig. 30). A scale placed on outside and a gauge glass determine the amount of the liquid inside. A perfect holder and distributor is illus-

FIG. 24.—COPPER BASIN.

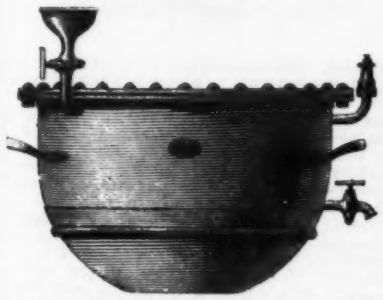


FIG. 25.—COPPER BASIN WITH DOUBLE BOTTOM, VALVES, PIPES, ETC.

FIG. 26.—FIXED BASIN FOR STEAM.

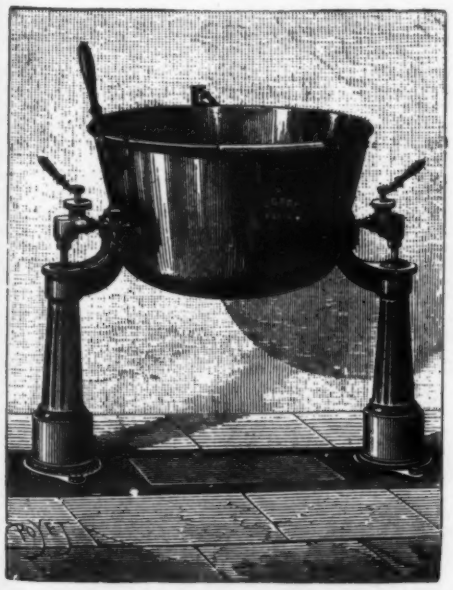


FIG. 27.—OSCILLATING BASIN FOR STEAM.

trated in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 516.

CHAPTER II.

Raw Materials.

SECTION I.—ALCOHOL.

In the useful arts the name spirits is given to alcohols which mark 70° on the alcoholometer of Gay-Lussac, the only legal standard recognized in France since the law of July 8, 1881, rendered effective by the decree of December 27, 1884. In commercial language, the different spirits are known under the names $\frac{8}{8}$, $\frac{7}{8}$, $\frac{6}{8}$, $\frac{5}{8}$, which are derived from an old method of estimating the strength of alcohol relating to brandy, called *preuve de Hollande*, marking 19° Cartier, which included about 50 per cent. of the volume of absolute alcohol. As we have already seen, spirits are produced from the distillation of wine, beets, molasses, grain, and potatoes. The distiller, or rather *liquoriste*, requires to make at least, if not absolutely, neutral spirits of good taste, because it is evident that if the spirits (alcohol) used have a pronounced taste, it will materially affect the product.

The principal kinds of alcohol used in France are named as follows:

The $\frac{8}{8}$ Languedoc.—Alcohol distilled from wine,

FIG. 28.—FILTER HOLDER.

strength 86°, very scarce at the present day. Used principally in making cognacs.

The $\frac{8}{8}$ Neutral, or Extra Fine.—Alcohol obtained by the rectification of alcohol, particularly from rice. It is of a strength equal to 90° to 95°.

FIG. 29.—BELLOWS AND COMPRESSED AIR SYSTEM FOR MOVING LIQUIDS.

The $\frac{6}{8}$ Fine of the North.—Alcohol from beets, rectified. It nearly always has a taste of the beet root. The spirits obtained by treating molasses are preferable. This alcohol is generally sold at 90°.

SECTION II.—ESSENCES.

Essences, or essential oils, have an oily look, generally very volatile, and are produced from a large number of substances in the vegetable kingdom, producing the odor of the plant. Their chemical composition is very complex. All odorous materials are generally very volatile, but at different temperatures. Their vapor tension is considerable, which explains the diffusion of the odor of flowers, as well as aromatic plants, to great distances. The essences are very volatile, as already

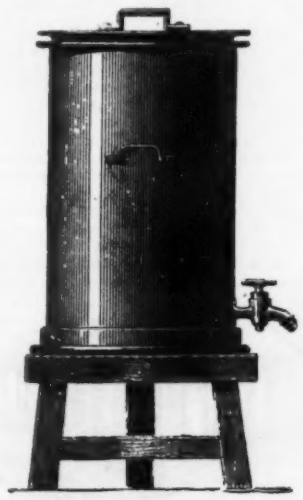


FIG. 30.

stated, and are in the liquid form at ordinary temperatures, except in rare cases. The greater part are uncolored, but some are colored yellow, brown, green, and even blue, all are soluble in alcohol, ether, chloroform, and light hydrocarbons; but, to speak properly, they are not dissolved in water, they are diffused only—that is to say, distilled waters owe their perfume only to minute drops of the essence, which are held in suspension, but it is not a perfectly homogeneous mixture, as the mixture of sugar and water.

Light has a certain action on essence. The air, by its oxygen, produces a great change, more or less rapid, producing a difference in the odor and a gradual resinification. The essences have variable specific gravities, some being lighter and some heavier than water. These points are very valuable when testing for adulterating materials.

Extraction of Essences.—The manufacture of essences is an industry of warm countries, and is extensively carried on at Grasse, Nice, and Cannes. Certain plants, such as the mint, are largely cultivated in the regions of the north. The industry of perfume making is, as is well known, of great antiquity, and

FIG. 31.—SCREW PRESS FOR OILS.

the process has remained almost unchanged until the present day. The processes of extraction are expression, distillation, maceration, and enfleurage.

Expression is a simple process, but it is rarely used, as it can only be profitably employed when the plant is rich in volatile oils. The skins of oranges and ci-

FIG. 32.—ZESTEUSE OF LESOULT.

trons are examples. The parts rich in essences are placed under the press, and the oils are extracted mechanically (Fig. 31). The mixture collects a good deal of water, but by repose, the essences separate and are removed by decantation (Fig. 33). In expres-

FIG. 33.—FLORENTINE RECEIVER—DOUBLE EFFECT.

sion a piece of apparatus for removing the rind of fruit (Fig. 32) is sometimes used. It is called in French a *zesteuse*. The pedals actuate two graters, which remove the skin in a short space of time.

Distillation is of ancient origin, and the apparatus

used in the manufacture of essential oils is often very crude, and only recently has the naked fire given place to steam as a source of heat. The products of distillation are usually received in flasks (Fig. 33), called Florentine receivers, which permit of the separation of the essential oil from the water. The watery portion contains a certain proportion of essence which cannot be removed; but this water can itself be used for a perfume. It is in this manner that rose water, orange flower water and others *can* be prepared. The delicate plants are treated as follows: The interior of the still is divided by a diaphragm pierced with holes, on which the plants are placed, this being submitted only to the action of the vapor which rises from below. The products are received as before. Distillation cannot be used for many plants, as the essential oil would be decomposed by a temperature of at least 100° C.

(To be continued.)

THE UNTRUSTWORTHINESS OF CERTAIN PHOTOGRAPHS FOR SCIENTIFIC PURPOSES.

A PROBLEM which has been mooted several times in this ecuntry and America is, "Can photography lie?" At the close of one meeting the chairman remarked that whatever photography might do, it had been proved in the course of the debate that photographers could lie considerably. Among engineers it may be of use to consider some of the elements of possible untrustworthiness in photographs, and that, too, without including extreme cases in which the original negatives have been altered by hand, as in the modern practice of retouching, so much encouraged by the personal vanity of many of the public. A master photographer, in giving instructions to his retoucher, may enter such items as these: Lengthen the nose of No. 247, take 6 in. off the waist of 42, broaden the chest of 149, reduce the ears of 253, take all the wrinkles out of the face of and thin down No. 27. The latter instruction possibly relates to a Mrs. Gamp, who has produced a portrait of Miss Ellen Terry, and said to the photographer, "I want to be taken like that."

The vagaries of photographic portraiture are little likely to interfere with the use of photography for scientific purposes. An element of uncertainty in all photographs is the alteration of scale, due to the unequal expansion of the paper in passing the positive through the washing waters and other liquids, after it has been printed under the negative. All papers under such conditions expand more in one direction than the other, and when mounted while wet, most of the distortion thus set up permanently remains. For ordinary purposes it does not usually attract attention, though in bad cases it sometimes produces so much distortion in portraits as to render them unsalable; in all cases it is present more or less, and unmounted photographic paper prints are constantly changing their dimensions with varying hygroscopic conditions. In fine scientific work, such as the production of enlarged paper prints of the lines of a large scale spectrum, this source of error becomes serious. Dr. H. W. Vogel, of Berlin, was once troubled with it when making such enlargements on bromide paper, so set to work to measure the variations under hygroscopic changes of three of the leading bromide papers in the market, with the following results, as set forth in the *Year Book of Photography* for 1889:

I.—Dimensions of the Original Negative.

Length mm.	Breadth mm.
224·4	137·4

II.—Dimensions of Prints on Bromide of Silver Paper, Measured after One to Five Days.

Kind of Paper.	One Day Fine Weather.			Two Days Fine Weather.			Three Days Fine Weather.		
			Contraction			Contraction			Contraction
	Lgth	Bdth	L. B.	Lgth	Bdth	L. B.	Lth	Bth	L. B.
Stolze	224·1	137·4	0 3	224	137	0·4 | 0 4	224	137	0·4 | 0·4
Just	223·5	137·25	0·9 | 0·15	223·1	137	1·3 | 0·4	222·9	137·1	1·5 | 0·3
Anthony	223·9	137·2	0·5 | 0·2	223 8	136·9	0·6 | 0·5	223·7	136·9	0·7 | 0·5

Kind of Paper.	Four Days Thick and Cloudy Weather.				Five Days Moderately Fine and Cool Weather.			
			Contraction				Contraction	
	Length	Breadth	Lth	Bdth	Length	Breadth	Lth	Bdth
Stolze	224	137·25	0 4	0·15	223·9	137	0 5	0·4
Just	223·25	137·15	0·15	0·15	223	137	1·4	0 4
Anthony	223·9	137	0·5	0·4	223·75	136·9	0·66	0 5

The papers tested were those of Stolze, of Berlin, Just, of Vienna, and Anthony, of New York. The table reveals that each paper shows a remarkable contraction after fixing, washing, and drying, and that the contraction is unequal in different directions.

Albumenized photographic paper usually contracts about 5 per cent. in one direction in drying. An American photographer is said to prize a sample of paper which expands abnormally when wet; a short, fat sitter he prints in one direction of the fibers, so that his portrait shall be lengthened in the washing waters; the prints are then mounted wet. People too tall and lanky he prints at right angles to the position just stated, so that they may be reduced in length and expanded in breadth in the portrait. A plan of mounting prints on albumenized paper, adopted by some of the best portrait photographers, is to starch the back of the prints while wet, then to let them dry. Afterward the face of the thick cardboard mount is damped with a cloth, the print is placed upon it, and both passed through the rolling press, whereby the print is affixed to the mount before the paper has time to expand under the influence of the dampness.

In photo-mechanical printing, in which great accuracy of scale in the results is necessary, the expansion and contraction of the papers under varying hygroscopic conditions are so troublesome that these sources of error have to be eliminated. Some years ago we saw a good method of getting rid of the nuisance in operation at Ixelles, in the photo-mechanical works of the military map department of the Belgian government. In one method of the reproduction of the Belgian ordnance maps a print is made on carbon tissue, and laid down dry in close contact with a sheet of copper, then upon the back of the carbon proof are placed four sheets of wet blotting paper, and without a moment's delay the whole is subjected to a pressure of 200 atmospheres in a hydraulic press. The effect of this is, that by the time the carbon tissue gets damp it is under such heavy pressure that it cannot expand. It is kept under the pressure for half an hour, after which it is developed, but under the circumstances to the true scale.

The present president of the Brussels section of the Belgian Photographic Association is Mr. A. De Blochouse, who then was a professional engineering photographer, and he, on the same principle, used a heavy screw press for the purpose. It was of about half the size of a four-post bedstead. The prints were first screwed down by means of the double-lever handle of the press. Extra pressure was then applied by means of a thick bar of iron, about 5 ft. long, fitting into any one of a series of holes round the axis of the top of the screw, capstan fashion. He said that surfaces brought together under pressure, after having been freshly coated with infinitely thin films of caoutchouc, deposited from solution, will afterward bear wetting without expansion of the design.

Some kinds of distortion in photographs may be due to the lens. Single lenses, such as used for landscapes, give barrel-shaped distortion of architectural lines when used in one way and pincushion-shaped distortion when used in another; this is not usually noticeable in photographs of landscapes pure and simple, representing trees and hills. With architectural subjects, the defect is most visible in what should be straight lines near the edges of the plate. Large lenses of all kinds throw imperfect images. For instance, let the aperture, A B, Fig. 1, of such a lens be for the

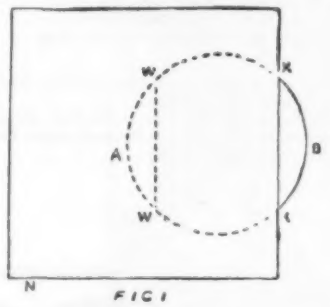


FIG 1

most part covered with an opaque screen, N N, a photograph can then be taken by means of the exposed part of the lens, K K; let K K now be covered, and another photograph taken with the now exposed part, W W; it is evident that both these photographs cannot be alike, for they face the object taken from different points of view, and the differences are most perceptible in objects near the foreground. Stereoscopic pictures have been taken in this way, and that without moving the lens. Thus, one side of a lens throws a different picture to the other side, and this is not conducive to scientific accuracy.

A pin hole in an opaque diaphragm throws a more perfect image than a lens, so far as true scale is concerned, and the hole is not so heavy to carry in portable apparatus as a lens, but the exposures with it have to be long, and at small distances from the hole the image projected is lacking somewhat in sharp definition. By adopting greater distances, and changing the diameter of the hole relatively to the distance in accordance with a known law, a point is at last reached in which the interposition of a lens will give no advantage at all in the matter of definition, as proved by Lord Rayleigh; but that distance is one of many feet.

At the last meeting of the British Association, at Edinburgh, Colonel Tanner brought before the geographical section the question of the value of photography in surveying, in place of the theodolite, and was in favor of it under circumstances in which there is no time to set up the latter instrument, such as when upon a mountain top, with clouds gathering. It was a pity that this paper was not read before Section A, where it could have been subjected to proper scientific criticism in the matter of the influences of the peculiarities of lenses.

The scale of the image thrown by a lens of long focus differs from that thrown by a lens of short focus, as regards the relative position of certain objects in the same picture. Some surveyors think that photography will abolish the theodolite, others that it is of comparatively little value. More attention has been given to this subject in France than here, and there the opinion is that the pinhole lens, if so it may be called, is of more use than a glass lens when exact measurements have to be made.

Lenses sometimes do violence to the perspective, or rather to the apparent perspective, for some lenses take in a much wider angle of view than does the human eye. Fig. 2, for instance represents the Girard

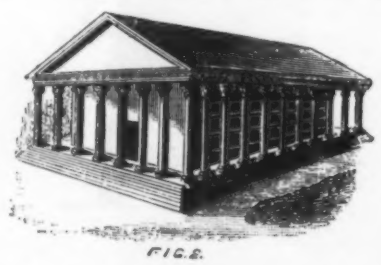


FIG 2.

College, in America, in the exaggerated perspective produced by a lens of very short focus; while Fig. 3 represents the same building in natural perspective taken by a lens of longer focus, not planted upon the same spot. Taking Gothic architecture, Fig. 4 represents the west front of St. Mark's Church, Philadelphia, taken with a lens of too short focus; and Fig. 5 represents the same front taken with a lens of longer focus. Any architect who wished for an engagement to design railway stations, and sent a photographer to take pictures of some of his past work in that way elsewhere—to place before the directors—might be wofully at the mercy of an ignorant man sent to do the work. The four architectural cuts just noticed are copied from Carey Lea's "Manual of Photography," Philadelphia, 1871.

A story was told at one of the London photographic societies, that a photographer had been engaged by the directors of a projected new railway to take pictures of the district, to prove that the proposed line would in no way injure the romantic scenery of a particular district, and that he executed the task. Then the opponents of the project went to the same man, and asked him to take photographs of the same district, to prove that the projected railway would be utterly ruinous to the scenery therein; he executed

FIG 3.

this task also. His employers were satisfied in both cases. Whatever truth or absence thereof may be in this story, the feat described is not impossible.

Frequently in this country, when proceeding by rail through beautiful scenery, especially upon one side of a valley with mountains upon the other, the prospect is marred by a hideous great board with the name of the station painted thereupon, and often of no use to the passengers in the other end of the train, who wish to know where they are. A bit of analogous unnecessary vandalism in this way has been perpetrated by some subordinate of the London County Council, by spoiling the best view of the Hampstead Heath fir trees, as they appear when entering the Heath from the Highgate road. The great notice board he has interposed does the mischief; had he but placed it on the opposite side of the road, he would have but hidden from sight a part of a common brick wall. The remedy at a railway station is to paint the name on all the lamps, where it shall be visible night and day, and from all parts of the train. Because a man is an engineer or railway director, it does not follow that his works shall show no sign of artistic taste, or of any of the refine-

FIG. 4

ments of life, and it is pleasing to see that the Great Western and one or two other railway companies are waking up in this matter in some of the new railway stations they are building near London.

A lens of too long a focus is as mischievous pictorially as a lens of too short focus; the former produces "flat" pictures, which do not seem to stand out in good relief. A good general rule is to take a photograph with a lens of the same focal length as the distance from which it is intended that the finished picture shall be viewed by the eye. For small pictures lenses of from 10 in. to 14 in. or 15 in. in focal length are good. In average photographs the attempt is almost invariably made to get too much into one picture; thus the distance is dwarfed.

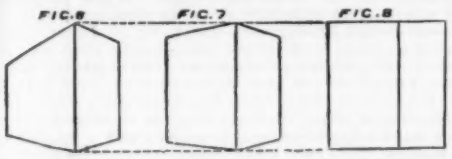
The following absurd paragraph appeared a few days ago in one of the London daily papers, evidently written by some non-technical critic, in the course of his description of the photographic exhibition at the Camera Club: "Mr. Van der Weyde shows some specimens of the effect of a new discovery of his, which is likely to have considerable influence on portraiture

FIG 5

in the future. He calls it the photo-corrector, and its object is to obviate that unsightly enlargement of the hands, feet, or other portion of the figure which occurs in certain poses in portraiture. Two examples were very striking. In one a lady sits looking out of the picture, her knees crossed, and her hands clasped round them. In the print from the original negative the hands and feet are abnormally large, but in a subsequent negative that is corrected, and the feet and hands are reduced to a proportionate size. The other is a portrait of the Princess Pless, the train of whose dress comes right to the front of the picture. In the first print this is distorted, with the result that the

figure is dwarfed. In the second print the train is reduced to due proportion, and the figure appears of the proper height. Although declining to go into details, Mr. Van der Weyde intimated that the correction is done by means of a lens on the principle of refraction." The differences described can simply be produced by substituting a lens of long focus for a lens of too short focus, in a studio of sufficient length, but the description given by the reporter is perhaps not entirely accurate. By means of a lens of exceptionally short focus with an excessively small stop, extraordinary distortion can be produced, of which Mr. W. K. Burton long ago executed some fine specimens for the amusement of the observers. Remarkable distortions can also be produced by the use of cylindrical lenses.

Dr. Vogel, having been moved by the surprise of photographers at the flat images given by lenses of telescopically long focus, has pointed out that the effect has nothing to do with the lens, but depends upon the great distance of the object. He illustrates his remarks by means of Figs. 6, 7, and 8, representing



theoretically the appearance of a cubical building, as seen at different distances, and how differently the horizontals converge at those distances.

The majority of photographs are taken with lenses of too short a focal length for good pictorial effect, and the whole class of hand camera photographs comes under this condemnation, the lenses used for them ordinarily being of from 5 in. to 6 in. in focus on a quarter plate. A lens of short focus, however, can often be used where it is impossible to get far enough from the object to employ a lens of long focus. In portraiture, the operator often works in a small glass house, in which he cannot get sufficiently far from the sitter for the best results; so is forced to use lenses of short focus, and in order to get sufficient light on the plate they must be of large aperture. With a long studio and plenty of light a common single landscape lens of long focus will give more accurate and pleasing portraits than many now turned out even by some first rate men. Another advantage of the single lens is the brilliancy of the image it throws, because of its small number of reflecting surfaces. With a lens of too long focus the pictures look flat; a landscape lens of about 12 in. in focal length is excellent for carte-de-visite portraits, when the light is good and the air free from mist; a certain amount of fog in the air will often compel the employment of lenses of shorter focal than desirable, to enable the camera to be brought nearer to the sitter.

A machine, especially one occupying approximately a cubical space, may have its parts greatly pictorially altered from the true relative scale, should the photographer bring the side swing of his camera into play, to bring the various parts of the object into sharper focus.—*The Engineer.*

PLASTER BUSTS FROM THE GREAT OASIS.

THE oases situated to the west of Egypt are little frequented by Europeans. The travelers who have visited them since the beginning of this century might be easily counted. They contain, however, important ruins—temples, of which some appear to date back to the seventeenth century before our era, fortresses of the Roman epoch, and basilicas and Byzantine churches. He who would desire to explore them methodically would find much to do, and would be richly rewarded for his trouble.

The inhabitants have not thought of exploring their riches. In recent years, however, the rumor of the discovery of antiquities, and the profit that the dwellers on the banks of the Nile derive from them, have reached the depths of their solitudes and have decided them to make excavations in their cemeteries. One has seen appear in the market objects of a peculiar style, glass work brought from the oasis of Favafrah, one or two stelæ, and some coffins, one all gilded, which figured at the exposition of 1889, in the Egyptian House of Garnier. It is from the Theban oasis that came to us the four busts of painted plaster which are now deposited in the museum of the Louvre, and which are reproduced herewith in about a sixth of their actual size.

The Theban oasis, the great oasis of the Græco-Roman geographers, extends from the northwest to the southeast, from about the level of Keneh to that of Assouan. It contains various groups of villages and cultivated lands, the principal of which are El Khargeh (called Knomou by the ancient Egyptians) and El Dakhleh, the Dosdes of Pharaonic times. It was occupied formerly by the Berbers and the Tamahous, who were independent of Egypt. A person who lived and was buried at Elephantina under the last kings of the sixth dynasty, about 3000 B.C., and who made three quite perilous voyages for them, found the oasis (Ouhait) independent, and boasted of having persuaded the inhabitants to acknowledge the suzerainty of King Memphitis. During the ages that followed, the Egyptian domination became established on a firm basis, and the worship of the Theban Amon was transported thither. At the beginning of the twelfth dynasty, El Khargeh was dependent upon the seignory of Abydos. Abydos, in fact, was the starting point of the shortest and easiest route. Five days sufficed to cover the distance that here separates the valley of the Nile and Hibit (El Hibeh), the chief place of the locality. The shackles of dependence, once forged, were never afterward broken. The indigenous Pharaohs, and then the foreign conquerors, Persians, Macedonians and Romans, devoted themselves to ornamenting with monuments these stations lost amid the sands. The western civilization entered at an early date, and Herodotus mentions the presence there, toward the middle of the fifth century before Christ, of Samians of the Æskhrionia tribe. They were doubtless traders, *bakals*, analogous to the *bakals* that are met with in our day dispersed by hundreds in the most remote cantons of Egypt. They were there upon the route of the caravans that did the trade of central Africa. The inhabitants of Soudan brought them, as now, gold, gum, ostrich feathers and ivory, and, in exchange, carried away glassware, fabrics and arms. This traffic, which is suspected rather than known, must have been considerable in the time of the Cæsars, and the Oasis enjoyed comforts and wealth that the resources alone of its soil would not have been able to procure for it.

The four busts of painted plaster were manufactured during these short years of prosperity, toward the end of the second or, rather, toward the beginning of the third century of our era. They are not, as might be supposed, pieces detached from full length statues. They are complete, with the exception of a few scales chipped from the edges during carriage.

They are mummy masks of a peculiar species, and like the majority of the objects that are admired in our Egyptian museums, they come from the tombs.

The dead belonging to good families were provided, from the ninth or eighth century before our era, in addition to their complete coffins, with forms that were put into the last coffin and attached to the mummy itself. These constituted for the deceased an armor in several pieces—a sort of boot, into which the feet were inserted, plastrons cut out and painted for the breast, a casque representing a human face painted and gilded, the blue or black wig of grand ceremonials, and the wide collar of eight or ten rows that covered the throat. The face often reproduced the lineaments of the deceased. It pretended to show, such as it was during life, the thin and contracted face concealed beneath the bands.

The forms were made of several thicknesses of fine linen, agglutinated, pressed into a mould, and covered with a layer of stucco or plaster upon which the artist did his best to delineate the features characteristic of the person buried. Toward the time of Augustus, masks of a different nature were substituted for them in several places: at Thebes and in Faioom, portraits painted with encaustic and set into the cover of the coffin at the location of the head, and, in the Oasis, half busts of painted plaster attached to the winding sheets by cords passing into apertures formed for this purpose in the edges. The bodies thus dressed out were placed in wooden or stone coffins, or simply placed on frames in ordinary tombs.

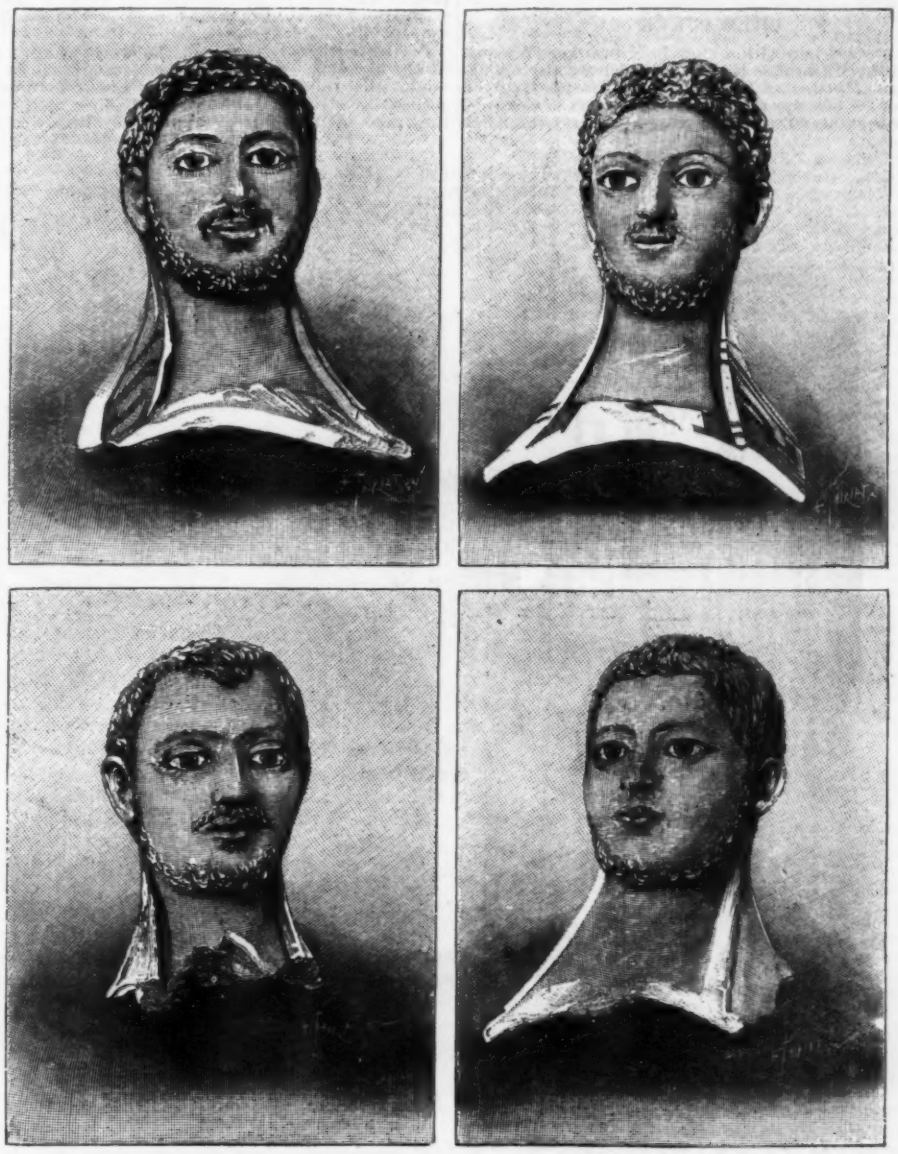
These are genuine portraits, then, that we have before us. The artists were obliged to shape the masks in the image of the dead, and the clearly characterized aspect of each of them shows us that here, at least, they are very cleverly conformed to the religious law. There is almost nothing of Egyptian in their work; it is the Græco-Roman style practiced by a very experienced workman.

Each bust has been formed in several pieces. The face is in a single piece, and the expression of it is such that one might say that it was a cast taken immediately after death. The eyes have been done over again, and, according to a process in use from the times of the first Pharaonic dynasties, incrusted with a thin layer of talc, which gives them the brightness of life.

The beard, mustache and frizzled hair have been applied afterward, as well as the ears and the neck, half concealed by the upper part of the clothing. The whole has been painted; the flesh in a tone that varies from dull yellow to reddish ocher, like that of the ancient Egyptian statues, and the hair and beard black bordering on russet. The white clothing is ornamented with a wide purple band or wavy lines inclosed between the heavy ones. It ascends very high behind the neck, and was usually embroidered at the upper part with scenes whose funereal intent it is easy to recognize.

There are two female figures, kneeling and dressed in the Egyptian style, the throat naked, the hair disheveled, one arm pendant and the other raised toward the forehead, in the attitude of the weepers at the funereal bed of a mummy. They differ in some details that the antique painter has badly interpreted or inadequately rendered, for want of knowing exactly what he was retracing. They are, in fact, the two divine weepers, Isis and Nephthys, who led the mourning over Osiris in fabulous times, and who, after that, were reputed to accompany with their lamentations the funereal procession of every Egyptian who died in the faith of Osiris. The remembrance of the myth began to get mixed in the mind of the people toward the age of the Antoninuses, and the manufacturers of coffins or objects for tombs no longer rendered, except in a summary way and by routine, divine scenes and persons, under which religious traditions obliged them to place mummies also. The magic representations of former times had for them scarcely more than a decorative value, and they prided themselves more on artistic fidelity than on mythological exactitude. They have succeeded in giving each of the physiognomies a very personal expression. All are more or less Egyptian, and at once recall faces that are caught sight of in the villages of Said, but all show a mixture of foreign blood. One of our men is almost a Syrian, with thick lips, puffed cheeks, and gross, shiny flesh.

Mr. De Villefosse has remarked the great resemblance that he presents with the portrait of Pescennius Niger. Another appears to have had some Semitic ancestor, perhaps a Jew. The third partakes of the Roman, and the last of the Lybian. The Oasis was a station of some importance, where state criminals or persons whom the emperor distrusted, wrongly or rightly, were often confined. It possessed a garrison composed of



ANCIENT BUSTS FROM THE GREAT OASIS IN EGYPT.

various elements, and we know well enough with what energy soldiers in garrison work in the fusion of races. The few French cantoned at Edfou, in 1800, are represented in the vicinity to-day by numerous families, of which several have preserved the remembrance of their origin and name themselves *El Fransaoui*.

Erment, where English and French engineers have succeeded one another since Mohammed-Ali, offers to the observer quite a remarkable collection of indigenous types mixed with French or English blood. The bailiff's men of the Cæsars must have singularly modified the Egyptian or Berber population of the Oasis, from the epoch of Augustus. About forty objects of this kind were brought to Cairo toward the end of the past year. One of them was bought for the museum of Copenhagen, but the Louvre possesses what was the best preserved in the lot. Our busts were kindly presented to it by Mr. Bouriant, director of our Cairo mission. They were presented to the Academy of Inscriptions and Belles Lettres by Mr. De Villefosse, who has set forth their rarity and interest This is not the only service of this kind that our museums and libraries owe to this archæological mission, so little known in France, but so greatly esteemed in foreign countries. It will render them many others if it is encouraged by those who have the power.—*G. Maspero, in La Nature.*

MILWAUKEE.

WE present herewith a view in Milwaukee, Wisconsin, on the Milwaukee River, for which we are indebted to the *Illustrated London News*. The great fire of October 28 last was the largest which ever devastated this prosperous city, as it destroyed property valued at several millions of dollars. The Milwaukee River divides the city into two unequal parts, in the smaller of which the fire occurred, and if it had not been for this separation of the city by the river, the fire might have almost rivaled the Chicago fire of 1871. At Milwaukee the city was left in almost total darkness, on account of the burning of the gas works and the electric light wires being severed. A gale blowing thirty-six miles an hour rendered the labors of the firemen futile for some hours. The light of the fire was seen from the tower of the auditorium in Chicago, eighty-five miles away.

Milwaukee is one of the most prosperous cities in the West, being delightfully situated on Lake Michigan, and from 1840 to 1890 the population has increased from 1,712 to 205,000 inhabitants. Some idea of the material prosperity may be gained when it is stated that one of its more important industries, that of brewing of lager beer, produces $12,000,000 per year. The commerce is very large, the tonnage entered and cleared being annually about as great as that of Baltimore or Philadelphia, while its railroad interests are very large, lines to the entire northwest radiating from Milwaukee. The flour and meat packing industries employ thousands of men. The city has a delightful climate and has the reputation of being very healthy. In the residence portion of the city there are many miles of shady avenues seventy to one hundred feet wide, lined with handsome houses usually detached. The use of a cream-colored brick gives a pleasing appearance to the city, and gave rise to the name by which Milwaukee is sometimes known, the "Cream City."

AN electrical gyroscope has been devised to show the rotation of the earth and to correct ships' compasses.

OPTICAL PROJECTION.*

THE intention of this lecture is to give a general survey of the subject of optical projection, which now takes its position in science, and to present examples of what may be done by this method. It would be difficult to determine which subject claims a first place. Some scientists say the microscope should have the preference, while others take a different view. For my own part, I think the microscope and polariscope stand foremost, on account of the facility with which these branches of science may be pursued for the benefit of a large number, without multiplying expensive apparatus; also because of the convenience in saving the eyes from undue strain. Indeed, to many persons, looking at objects in the table microscope is little short of a painful operation, and consequently the study of small objects becomes to them impossible. The projection method immediately brings the required relief.

For general instruction, projection methods are invaluable, such as, for instance, showing diagrams, photographs, and other slides, upon the screen; as well as for spectrum analysis. In fact, the subjects which can be illustrated by means of optical projection are innumerable; but time will allow me to present only a few examples, and I trust that, when I approach the end of my lecture, my view of the importance of this subject will be held in equal estimation by you.

Probably the only people in the world that benefit by the experience of their predecessors are those who pursue the study of science. They are free from the accusation of robbing the brains of other men, when they take up methods or apparatus already known and improve upon them or employ them for their own work. In such cases, however, it is always understood that honor should be given where honor is due, and accordingly I have no wish to represent to you any piece of apparatus as of my own devising, when in reality it belongs to another.

Few men have had a larger experience, and attained greater success in optical projection, than has Mr. Lewis Wright, who has embodied in his most recent forms of apparatus all that was good in designs existing until his time. I have, therefore, started from his models, making such modifications as I thought to be desirable. Mr. Wright does not appear—if I may say so—to have had much experience with the electric arc light as a radiant, and I found, at a very early stage, that great difficulties had to be encountered when this light was used, chiefly because the radiant approaches more nearly to what theory requires. That which was easy with the lime light became almost impossible with the arc lamp, and these difficulties had to be conquered.

Many scientific men are dissatisfied with the projection microscope, on the ground that very high magnification does not give that resolution and that sharpness which is found in the usual methods of observation. This want I fully admit. At the same time it is scarcely right to condemn a particular method because you try to apply it to an unsuitable purpose. Hundreds of thousands of subjects may be shown with the projection microscope with far greater profit to the student than was possible in the old way. The very fact that the professor can place his pointer upon any part of the picture on the screen is invaluable to the students. I shall, therefore, attempt to show you only a series of microscopical subjects suitable for projection, and shall not employ very high magnification.

In regard to some substances very high powers may be used with advantage, but much time would be lost in getting them into the field and focusing them upon the screen. These, consequently, I omit, so that a large number of subjects may be illustrated.

It is fair to state that most of the apparatus used to-night has been constructed by Messrs. Newton, of Fleet Street, and the luminous pointer by Messrs. Steward, of the Strand. The arc lamp is a Brockie's projector. Messrs. Baker, Watson, and others have also come to my assistance.

I will first show, on the screen, a picture of the lantern carrying its various apparatus; and then a few systems of lenses, which may be employed for the projection microscope, as well as a diagram of the microscope itself.

Sub-stage condensers and objectives are, as a rule, made to suit the table microscope. When projecting by means of an objective alone, in consequence of the screen distance being very great—or, in other words, the microscope tube being exceedingly long as compared with the table instrument—the objective has to be approached very close to the slide; in fact, with the higher powers, closer than the cover glass will allow. This close working distance renders necessary special sub-stage condensers, and in many cases a special one is required for every screen distance with each objective. This requisite would seem to be a complete stumbling block to microscope projection work. With the lime light the difficulty does not enter in the same degree as with the arc light, and as we are now dealing with the latter, further reference need not be made to the oxyhydrogen light. There are two ways of surmounting the difficulty; one by the use of plano-concave lenses, introduced in such a way as to be equivalent to greatly lengthening the focus of the objective on the screen side, while it enables, as a consequence, the objective to be slightly further removed from the slide, *i. e.*, giving what is termed a greater working distance. The objection to this method is that, even when these plano-concave lenses are corrected, the result, though greatly improved, is not perfect. The second way, which is a perfect one, is that of introducing an eye piece. In both these methods, that the best results may be obtained, the objective is made to occupy a position not very different from that which it would do if employed on the table microscope.

In the eye piece method almost the exact conditions can be complied with for which the objective was made. I propose, therefore, to show the subjects by the eye piece method. The only objectives which will be used are: (1) Zeiss's 35 millimeter projection objective, with a sub-stage condenser, 4 inches focal length, placed a considerable distance from the slide; (2) Newton's 1-inch projection objective, the sub-stage condenser as in the first case; and (3) Zeiss's ¼-inch achromatic objective, the sub-stage condenser being Prof. Abbé's three lens condenser with the front lens removed. In all three cases the eye pieces used are Zeiss Huyghens No. 2 and No. 3.

In each instance I will mention the magnification in diameters, as well as the number of times when reckoned by area, for the appreciation of those who estimate by area; and I will also give the size to which a penny postage stamp would be increased, supposing it to be made of India rubber, and stretchable to any extent in all directions. In presenting these figures I

* Friday evening discourse delivered by Sir David Salomons at the Royal Institution, on February 26, 1892.—*Nature.*

VIEW IN MILWAUKEE ON THE MILWAUKEE RIVER.

do not pretend that they are absolutely correct, but as they have been ascertained under conditions similar to those now existing, the errors will not be very great.

In consequence of the field not being quite flat, and the sections having a certain thickness, although extremely thin in most cases, the whole of the object cannot be in focus upon the screen at the same time. By shifting the focusing screw slightly all parts may be brought into focus successively. So-called greater depth of focus is obtained by using an increased working distance; and for projection work over-correction for flatness can alone give a sharp picture all over with very considerable depth of focus: the difficulty of over-correction being that, unless extreme care is taken, certain forms of distortion may be introduced. By stopping down the objective greater flatness of field may be secured, but at the expense of light. There is thus a choice of difficulties, and the least one should be taken.

Turning now to the polariscope. Polarized light teaches us a great deal concerning the structure of matter; it is also a means of confirming the undulatory theory of light. This subject is so large that no attempt can be made to give even a general idea of the field it covers, and the experiments, which will be shown in the polariscope, may be taken simply as a few illustrations of the subject and nothing more; but they will, at any rate, be suggestive of the large field to which this method of analysis can be applied. A vast amount of mathematical proof can be illustrated graphically by various experiments with polarized light. I will show on the screen a diagram of the polariscope. (Shown.)

With reference to showing the spectrum. The method of projecting a spectrum, I think, is new, as I have not seen it described anywhere. It gives practically a direct spectrum with an ordinary prism, without turning the lantern round to an angle with the screen; and here is a diagram of the method.

The details of the apparatus, as well as those of the methods of working, I have modified in almost every instance, for five reasons: (1) That more certain results may be insured; (2) that rapidity may be obtained; (3) that only one operator may be needed; (4) that, as far as possible, all parts of the apparatus may be interchangeable; and (5) that loose screws and pieces may be dispensed with.

There were then shown by projection a number of slides illustrating various microscopic optical systems, and a number of microscopic slides, followed by a series of general polariscopic projections, some of them to illustrate the strains existing in many forms of matter; also a spectrum by a carbon disulphide prism, in conjunction with a reflecting prism and with a mirror, which, apart from any other result, demonstrates that the loss of light with a reflecting prism is less than with an ordinary glass mirror. Slides and other projections were also thrown upon the screen.

The details are as follows:

The Microscope.—Screen distance, 21 feet. First 35 millimeters Zeiss projection objective, 4-inch sub-stage condenser, Zeiss Huyghens eye piece 2; 500 diameters = 250,000 times = penny stamp stretched to cover about 147 square yards. Subjects shown: proboscis of blowfly; permanent molar displacing milk tooth (kitten); human scalp, vertical; human scalp, surface; fossil ammonites and belemnite. Second, 1-inch Newton's projection objective, 4-inch sub-stage condenser, Zeiss Huyghens eye piece 3; 1,000 diameters = 1,000,000 = stamp stretched to about 588 square yards. Objects shown: proboscis of blowfly; foot of a caterpillar; section of human skin, showing the sweat ducts; phylloxera vastatrix of the vine. Third, 1-inch Newton's projection objective, 4-inch sub-stage condenser, Zeiss Huyghens eye piece; 1,300 diameters = 1,690,000 times = stamp stretched to about one-fifth of an acre. Slides shown: proboscis of blowfly; wings of bee (showing hooklets and ridge); sting of bee (showing the two stings, sheath and poison sack); sting of wasp (showing same as last slide); eye of beetle (showing the facets). Fourth, ¼-inch Zeiss's achromatic objective: Abbé's 3-lens sub-stage condenser, with top lens removed; Zeiss Huyghens eye piece 3; 4,500 diameters = 20,250,000 times = stamp extended to nearly 2½ acres. Slides shown: proboscis of blowfly; hair of reindeer (showing cell structure); hair of Indian bat (showing the peculiar funnel-like structure); sting of bee (showing the barbs); foot of spider; stage of the micrometer (the closest lines ruled to thousandth of an inch, which measure 4½ inches apart under this magnification); a wave length $\frac{1}{40000}$ inch, therefore, on screen measures about ⅛ inch.

The Polariscope.—Shown with parallel light: plain glass; glass under pressure; chilled glass (round, oval, and waved peripheries); Prince Rupert's drop (broken in the field); horn; selenites (overlapped); butterfly (selenite); bunch of grapes (selenite); bi-quartz, with ¼ wave plate (the ¼ wave plate in this experiment produces the same effect upon the bi-quartz as if a column, 20 centimeters long of a 7½ per cent. solution of cane sugar were placed between the polarizing nicol and the bi-quartz; the analyzer has to be rotated about 10 deg.); a piece of sapphire to show asterism. Shown with convergent light; hemitrope (cut in a plane, not at right angles to the axis); ruby, topaz, grape sugar (diabetic), cane sugar, quartz, superposed right and left handed quartz (spirals); calcite and phenakite superposed (showing transition from negative to positive crystal, passing through the apopholite stage).

The Solidiscope.—New form of apparatus for showing solids, and consisting of two reflecting prisms and suitable projecting lenses. With this instrument were shown, Barton's button, the works of a watch, a coin.

Spectrum Analysis.—Spectrum thrown by means of a disulphide prism combined with a reflecting prism; the result being that a good spectrum is thrown upon the screen direct without turning the lantern. There were shown: The spectrum; absorption bands of chlorophyl, etc.; effects produced by passing the light through colored gelatine films.

Projection of Slides.—Decomposition of water; expansion of a wire by means of heat; combination of colors to form white light; various diagrams, colored photographs of a workshop, etc. As an extra experiment there was shown, in the polariscope, with a convergent light, Mitscherlich's experiment (illustrating the changes which take place in a selenite under the influence of heat).

There are but few who would disagree with me in the opinion that the microscopic world, as regards its design and its molecular structure, is quite as wonderful as the great works around us seen with the unaided eye. A magnifying glass of low power opens up a world far larger than that which we are accustomed to see. At the present time, even with the most perfect apparatus that exist, only a small portion of the universe is known to us.

Scientific study should be pursued by all in a greater or less degree. It teaches more important lessons than the most impressive discourse ever preached. During the investigation of what is generally termed the invisible world, men should at times pause to reflect, and ask themselves such questions as these: What is the meaning of, and to what end is, creation? Is it all mere chance? Were such wonderful designs and properties created at the beginning? Was there in matter at the beginning an inherent, or implanted, power of development? Simple as these questions may seem, man in the flesh will never be able to find the true answers. The extraordinary design and structure which have existed in the unseen world for millions of years, or possibly in all past time, and even at the present day known to so few, demonstrate at least that the great Power has bestowed the same care upon what appear to us the most insignificant portions of creation as upon what we think are the greatest works in the universe. These silent sermons must surely influence the mind, and set it thinking of the supernatural and of our duties during life.

It may now with truth be said that science gives us means, such as never before existed, of appreciating the greatness of the Supreme Spirit, by enabling us to read fresh chapters in the book of nature.

THE INFLUENCE OF ALCOHOL UPON THE LIVING HUMAN SYSTEM.*

By N. S. DAVIS, M.D., LL.D., of Chicago.

WE are assembled to note the first anniversary of this association, which was organized in Washington, D. C., May, 1891. The objects had in view by those who participated in its organization, as declared on that occasion, were "to advance the practice of total abstinence in and through the medical profession, and to promote investigation as to the action of alcohol in health and disease; and to form a bond of union among medical abstainers all over our country." That those three objects are of sufficient importance to challenge the attention of every well informed and unbiased member of the profession, must be admitted by all. Especially is this true if we consider the fact that more than $800,000,000 are annually paid for alcoholic drinks, fermented and distilled, by the people of this country; over $700,000,000 by the people of Great Britain; and nearly in the same ratio by all the nations occupying the Continent of Europe; and all this without returning so much as a single cent to the consumers who pay the money, or a pound of bread for their families. If we also consider the fact that all our highest judicial authorities and social economists attribute much more than half of all the pauperism and crime, in the same countries, to the use of those drinks, while the highest authorities in our own profession freely admit that a large percentage of the sickness and mortality is traceable to the same source, we shall be compelled to admit that there is no other topic more imperiously demanding the candid, persistent and thorough investigation by every practitioner of the healing art than that which relates to the real influence of alcohol directly upon the living human system and indirectly upon the collateral interests of the race.

To make such investigation accurately and reliable, the investigator must himself be free from the deceptive and perverting influence of the alcohol upon his own brain and blood. In the language of our Code of Ethics: "It is incumbent upon the faculty to be temperate in all things, for the practice of physic requires the unremitting exercise of a clear and vigorous understanding; and in emergencies, for which no professional man should be unprepared, a steady hand, an acute eye, and an unclouded head may be essential to the well being, and even life of a fellow-creature." Hence, our by-laws require the practice of total abstinence from alcoholic drinks by the members of this association, although they place no restrictions upon the conscientious use of alcohol in the treatment of disease. To determine more accurately the origin, nature, physiological effects, and therapeutic uses of alcohol, and to diffuse a knowledge of the same, both in and out of the profession, is the paramount object of our organization. As an association we have nothing to do with the political parties and questions of the day, whether of prohibition, high license, low license, protection, free trade, or reciprocity. Our work is one of strict scientific inquiry and investigation. Professor Schmoller, the economist, of Germany, says: "Among our working people the conditions of domestic life, of education, of prosperity, of progress, or of degradation, are all dependent on the proportion of income which flows down the father's throat. The whole condition of our lower and middle classes, one may even without exaggeration say the future of the nation, depends on this question." As the same may be said with equal truth concerning our own people, it certainly becomes us, as the professional guardians of the public health, to ascertain more certainly the nature and effects of those drinks that "flow down the father's throat," and which carry with them the income on which depends the domestic happiness, the education, the prosperity and much of the health of the whole community. It is hardly necessary to say that the one essential ingredient in all the "drinks," here spoken of, whether fermented or distilled, is alcohol. It is not found as a proximate element in living organized bodies, either vegetable or animal, but is exclusively the product of bacteriological action on glucose or saccharine matter, constituting the process known as vinous fermentation. In other words, the alcohol is an effete toxic product resulting from the action of the micro-organism known as the torula cerevisiæ, of Turpin, on sugar or glucose, and is composed of C_2H_6O. It is therefore chemically a pure carbo-hydrate, and early in the progress of analytic and organic chemistry, it was unfortunately classed by Baron Liebig with those carbo-hydrates resulting from vegetable growth or nutrition, starch, sugar, gum and cellulose, as supporters of combustion or respiratory food when taken into the human system. Such classification was not founded on the results of any scientific investigations showing that the actual effects of alcohol, starch, sugar, etc., when taken into the living system, were similar, but solely on the fact that they were all composed of the same ultimate elements, carbon, hydrogen, and oxygen, in such proportion as to admit of further oxidation outside of the living body.

And as such oxidation or combustion was accompanied by the evolution of heat, it was assumed, without experiment or proof, that all these carbo-hydrates were oxidated in the living system, and were active supporters of respiration and animal heat, while the various organized animal tissues were developed and nourished from the nitrogenous proximate elements of food. The simplicity of such a classification of foods and animal tissues, aided by the high authority of Liebig, caused it to be universally accepted and thoroughly incorporated into both medical and general literature, where, in the public mind at least, it still remains; and is a fair illustration of the danger or fallacy of assuming that similarity of chemical composition is proof of similarity of action when taken either as drink, food, or medicine.

From a somewhat extended investigation of the subject, I think it may be stated as a general law that all the orders of animal life are dependent for their development, growth, and nutrition upon materials resulting from either vegetable or animal growth. Certainly, none of the higher orders of animal life assimilate and appropriate for the growth or repair of their structures and the support of their physiological processes inorganic materials not previously combined under the formative or vitalizing influence of vegetable or animal life. It may be further stated as an equally general law, that the products of retrograde metabolism or tissue metamorphosis as presented in the excretions and eliminations from living bodies, both vegetable and animal, are not only not capable of being used as food, but are either inert or positively toxic if retained or reintroduced into the living body. Hence we have a clear and most important distinction between such carbo-hydrates as starch, sugar, gum, cellulose and dextrin, resulting from vegetable and animal nutrition, and the alcohols, which result solely from retrograde metamorphosis or bacteriological excretion, usually termed fermentation. And instead of acting alike as respiratory or indirect food, as has been claimed so long, all the strictly scientific investigations of the last half century have proved their action upon the structures and functions of the living body to be as diverse as their origin. Thus the carbo-hydrates of the first class named, starch, sugar, gum, etc., when taken into the healthy stomach, readily undergo such digestive and assimilative or molecular changes that their identity is not recognizable in either the blood or tissues of the healthy animal, and the products derived from them produce no unnatural excitement or disturbance in any of the functions and processes of the living body. Though taken in proper quantities daily from year to year, they create no craving or morbid appetite for more; and when the quantity taken at one time is excessive, such excess is rejected with the ordinary fæcal matter of the intestines.

But the alcohols constituting the second class undergo no such digestive or assimilative changes in the stomach or digestive apparatus. If the ordinary ethylic alcohol is taken into the living stomach undiluted and absolutely pure, it acts directly upon the tissues with which it comes in contact as a destructively corrosive poison, and speedily destroys the life of both vegetables and animals when brought in contact with them. When largely diluted with water, as it is in the various fermented and distilled liquors, and taken into the stomach, it is rapidly imbibed, without change, and carried directly into the blood, and with it, into every tissue and organ of the body, as has been demonstrated by the application of reliable tests many hundred times. More or less of it also soon reappears in the excretory secretions and eliminations of the lungs, skin, and kidneys, like other foreign or non-assimilable materials. While retained in the blood and in contact with the tissues, the alcohol modifies in a marked degree the sensibility of the nervous structures, and also the molecular or metabolic changes concerned in nutrition, disintegration, and sensation. If taken daily for a considerable length of time, it invariably creates a morbid appetite or craving for steadily increasing quantities, and sooner or later establishes degenerative changes in nearly all the organized structures of the body. It is obvious, therefore, that there is actually no similarity or analogy, either histological or physiological, between the carbo-hydrates of vegetable and animal growth and those derived from bacteriological or putrefactive fermentation. And the time has fully come when the purely theoretical, and most mischievous error of grouping them together as respiratory and force-generating food should be corrected in all our literature and eradicated from the public mind. Half or three quarters of a century since, when alcohol was placed at the head of the list of respiratory foods by the chemico-physiologists of that day, it was claimed that when taken into the living body it readily combined with oxygen, and was resolved into carbon dioxide and water, with the evolution of heat; and hence it came into almost universal use as a supposed stimulant and promoter of animal heat. Step by step, however, investigations, carefully devised and faithfully executed, have not only demonstrated this supposition to be erroneous, but they have equally demonstrated the real action of alcohol in the living human system to be that of an active anæsthetic, directly diminishing cerebral and nerve sensibility and muscular action; a retarder of the internal respiration, by which oxygen is carried from the pulmonary to the systemic capillaries; and a sedative or retarder of the molecular or metabolic changes in the tissues and secreting structures of the body. These several propositions have been so fully sustained by the direct experimental investigations of Prout, Böcker, myself, Richardson, Anstie, Hammond, Harley, Sidney Ringer, Martin, H. C. Wood, Lauder Brunton, Dubois, Reichert, and many others, that it would be superfluous to quote

*Annual address before the American Medical Temperance Association, Detroit, June 9, 1892.—*Quarterly Journal of Inebriety.*

them in detail. There are, however, still many, both in and out of the profession, who claim that the alcohol is an anæsthetic only when given in large doses; while if given in smaller doses and repeated at suitable intervals, they claim it acts as a stimulant and tonic, especially on the cardiac nerves. The incorrectness of this claim is completely demonstrated by the investigations of Drs. Ringer and Sainsbury, Professors Martin and H. C. Wood.

The experiments of Sidney Ringer and Harrington Sainsbury were instituted for the purpose of determining the relative strength of different alcohols as indicated by their influence on the action of the heart of the frog. In closing their report on the subject they say: "By their direct action on the cardiac tissues these drugs (alcohols) are clearly *paralyzant*, and that this appears to be the case from the outset, no stage of increased force of contraction preceding."

The experiments of Professor Martin, of Johns Hopkins University, were performed on the dog, and he states the results obtained as follows: Blood containing ¼ per cent. by volume of absolute alcohol has no immediate action on the isolated heart. Blood containing ½ per cent. by volume, that is, 2½ parts per 1,000 of absolute alcohol, almost invariably remarkably diminishes, within a minute, the work done by the heart; blood containing ½ per cent. always diminishes it, and may even bring the amount pumped out by the left ventricle to so small a quantity that it is not sufficient to supply the coronary arteries."

Professor H. C. Wood, of the University of Pennsylvania, also executed his experiments on the dog, and in his address to the International Medical Congress at Berlin, 1890, states his results as follows: "An 80 per cent. fluid (alcohol) was used, diluted with water. The amount injected into the jugular vein varied in the different experiments from 5 to 20 cubic centimeters, and in no case have I been able to detect any increase in the size of the pulse, or in the arterial pressure, produced by alcohol, when the heart was failing during advanced chloroform anæsthesia. On the other hand, on several occasions the larger amounts of alcohol apparently greatly increased the rapidity of the fall of the arterial pressure, and aided materially in extinguishing the pulse rate." That alcohol exerted, not only a general anæsthetic effect upon the nervous system, but also a special or direct paralyzing influence on the cardiac and vaso-motor nerves, strictly parallel with that produced by chloroform and ether, was clearly shown by R. Dubois in 1883. And the editor of the department of experimental therapeutics in the fifth volume of the Annual of Universal Medical Sciences, 1892, in referring to the review of the work done by nearly all those who have engaged in experimental investigations regarding the effects of alcohol on the living system, by E. MacDowell Cosgrove, truly says: "Contrary to what has been and is supposed, it is found from all these researches that small doses of alcohol, from the first, produce a narcotic rather than a stimulating effect." And he adds that all the observers except one had "also found that alcohol in small doses diminished the amount of carbon dioxide exhaled." It is thus shown, by the direct experimental researches of the most eminent men in different countries, aided by all the instruments of precision invented in this period of active scientific progress, that alcohol in the living system actually diminishes the sensibility and action of nerve structures in direct proportion to the quantity used. An ordinary regard for scientific accuracy, therefore, demands that it should be classed as an anæsthetic or narcotic, and in no sense as a stimulant or tonic. In studying further the mode by which alcohol produces its effects while in the living human system, it is necessary to appreciate the full import of the following propositions:

1. All nerve sensibility and force, and all natural molecular or metabolic changes, nutritive, secretory, and disintegrating, taking place in the living tissues, are absolutely dependent on the presence and movement of blood containing its natural proportion of oxygen.

2. The oxygen needed in the blood is received from the pulmonary air cells by the hemaglobin and serum of the blood, and in them conveyed to the systemic capillaries, where it comes in contact with, and exerts its influence on, every cell and structure of the body.

3. Alcohol at ordinary temperatures of the air, or even of that of the living human body, manifests but a very feeble affinity for oxygen, but does manifest a very strong affinity for water, albumen, and hemaglobin, acting upon them readily at all ordinary temperatures.

If, therefore, alcohol, sufficiently diluted to permit its circulation in the blood, should be introduced, either by the stomach or any other method, instead of uniting with the oxygen, it presents its superior affinity for the hemaglobin and serum albumen, and thereby directly interferes with their reception of more oxygen from the pulmonary air cells. It is thus that the presence of the alcohol hinders the hemaglobin from being converted into oxy-hemaglobin in the pulmonary capillaries, and in the same ratio diminishes the amount of oxygen conveyed to the systemic capillaries; and in the same ratio, also, the nerve sensibility and metabolic changes diminish. This affords a full explanation of the facts now admitted by all who have carefully studied the subject, namely, that the presence of the alcohol retards both nutritive and disintegrative changes, diminishes excretory products and temperature, and lessens nerve sensibility and force.

An explanation of these admitted facts has been hitherto, and still is, sought for on the supposition that the alcohol simply unites with oxygen of the blood, and thereby prevents or diminishes the action of the latter on the tissue elements of the body, and yet generates heat and some kind of force. The fatal defect in this old combustion or oxidation theory is, that no investigator has been able to find the legitimate products of such oxidation. So far as is known, the oxidation of alcohol resolves it into either aldehyde, carbon-dioxide and water, or acetic acid, and evolution of heat. Consequently, if alcohol underwent oxidation in the system, some increase of one or all of these products should have been uniformly found, either in the blood, the exhaled air, or in the other excretions. But instead, the most accurate and numerous investigations show less carbon-dioxide in the exhaled air, less temperature of the body, and neither acetic acid nor aldehyde in the blood.

And yet the puzzled investigators turn and say that, inasmuch as the alcohol disappears in the system and cannot be all regained from the secretions and eliminations in a limited time, it *must* have been oxidized, and converted into some kind of force. But what force? Certainly not nerve force, mental force, muscular force, heat force, or metabolic force; for all of these are directly diminished by its presence. The only force found operative in the case is the superior affinity of the alcohol for the hemaglobin, albumen, and water of the blood; and its toxic power to so modify their molecular condition and properties as to diminish their efficiency in receiving and conveying the oxygen from the pulmonary to the systemic capillaries, and thereby impairing all the vital processes in which the presence of oxygen is required.

This view enables us to see the philosophy or *rationale* of those illusions and delusions that have been imposed upon the human mind by the use of alcohol in both health and disease through all the generations of the past. Thus a moderate dose in health, by its anæsthetic effect on the nerve cells of the brain, lessens the individual's consciousness of cold or heat, of weariness or despondency or weakness, and he is deluded with the idea that it had warmed and cheered and strengthened him, when it had done neither; but instead, had simply diminished the acuteness of his own perceptions while the evils continued in full force. So in the progress of disease, its use generally has the same anæsthetic effect, causing the patient to complain less, rest more, and often say he feels better; but it neither removes the exciting cause, nor corrects the morbid processes constituting the disease, nor increases the activity of the metabolic changes of either nutrition or elimination. Nor is this all. For in the same proportion as the alcohol diminishes the internal distribution of oxygen, and thereby acts as a so-called conservator of tissue, it still more actively interferes with the katobolic processes by which the natural excretions are maintained and foreign disturbing elements are eliminated, and consequently it prolongs the morbid processes, favors molecular degenerations, and increases the ratio of mortality. Clinical facts and cases could be cited in abundance, illustrating and sustaining the correctness of the foregoing views, did my time permit. I will, however, at present only add for your consideration the following questions:

1. If the physiological standard of health requires a natural degree of sensibility of the cerebral hemispheres and the internal distribution of oxygen in natural quantity, and the presence of alcohol diminishes both in direct ratio to the quantity taken, how is it possible for persons in health to use it without injury?

2. If the alcohol, while in the living system, does thus diminish the sensibility of the nerve structures and retard the internal distribution of oxygen, is it not a true anæsthetic and organic sedative, and, therefore, adapted to the treatment of only a very limited number of morbid conditions presented in the progress of disease?

3. Is it not true that all the fermented and distilled alcoholic liquors are genuine toxic products of bacteriological cultures, and ought we not to uniformly designate them as such, instead of continuing to delude ourselves, our patients, and the public generally by calling them tonics, stimulants, or indirect food?

NITRATED SILK.*

By L. VIGNON and P. SISLEY.

WHEN silk is immersed in ordinary nitric acid (sp. gr. 1·133) at 45° for one minute, and is subsequently washed in water, it is colored intensely yellow, and the color is unaffected by exposure to air and light, while it is deepened by the action of dilute alkali solutions. Nitric acid free from nitrous compounds does not cause this coloration, which is found to vary in intensity directly with the amount of nitrous compounds present, and with the temperature and specific gravity of the acid used. The deepening of color by alkaline solutions is independent of their causticity, while the silk increases in weight and takes up a certain amount of the base.

Silk treated with a mixture of hydrochloric acid and sodium nitrate is colored pale yellow; the color is rapidly browned on exposure to air and light, or by the action of boiling water or alcohol, while cold alkaline solutions turn it reddish brown. Silk which has been subjected to the action of nitrous acid, or of nitric oxide, in an atmosphere of carbonic anhydride, and subsequently well washed, is colorless, but is colored a stable yellow by nitric acid. Nitric peroxide colors silk yellow at once. Silk heated with nitrous acid, and then oxidized with potassium permanganate and hydrochloric acid, is colored exactly as by nitric acid (impure), from which it seems that the yellow coloration is dependent on the action of nitrous compounds, and subsequently of an oxidizing agent.

The yellow color is discharged by acidified stannous and chromous chloride solutions. Analyses of the nitrated silk show that about 2 per cent. of nitrogen is fixed in the reaction, probably, primarily, as the nitroso group, which the further action of the nitric acid converts into the nitro group, a carboxyl group being displaced. The properties of the product somewhat resemble Mulder's xanthoproteic acid, but this contains more carbon and less nitrogen, and results from a more intense action. Sulphuric acid dissolves ordinary silk gradually to a slightly colored solution, whereas nitrated silk is converted into a pale yellow viscid mass. Aqueous potash dissolves ordinary silk in the cold, and nitrated silk on heating; neither solution is precipitated by dilution with water, and both evolve ammonia when heated. Both varieties of silk are dissolved by hydrochloric acid and by zinc chloride solution.

Ammoniacal vapors are evolved on distillation of each variety, and a carbonaceous residue is left. On ignition, nitrated silk burns more rapidly than ordinary silk.—*Am. Jour. Phar.*

* *Bull. Soc. Chim.* [3], 6, 808; *Jour. Chem. Soc.*, September, 1892, p. 1111.

[Continued from SUPPLEMENT, No. 884, page 14134.]

OLEOMARGARIN.*

By Prof. G. C. CALDWELL, Cornell University, Ithaca, N. Y.

BEYOND what I have given you in what has gone before, I find nothing more in the literature of this subject for the past twenty years that relates to the question of the danger to health in the use of oleomargarin, except numerous statements by scientific men of eminence in this and other countries. Morton, President of Stevens Institute; Chandler, of Columbia College, for so many years president of the New York City Board of Health; Johnson and Brewer, of Yale, both well known by farmers throughout the country for the good work they have done in behalf of agriculture; Goessman, now and for many years past director of the Massachusetts Agricultural Experiment Station; Atwater, of Connecticut, so well known for his writings on food products; Armsby, director of the Pennsylvania Experiment Station; Alvord, most prominently identified with the interests of farmers for many years, and now director of the Maryland Experiment Station, all have spoken or written in favor of oleomargarin as a food product. It has required the courage of their convictions for many of these men to utter their opinions; and they have in many cases had only the comfort of a clear conscience to offset the abuse of the agricultural press that has been heaped upon them. Abroad, I would mention particularly Lyon Playfair, one of the most distinguished chemists and sanitary authorities of England. In his place as member of Parliament, he spoke in a very different strain from that indulged in by some of our Congressmen, when he said: "As to the relative wholesomeness of oleomargarin and butter, I do not think there is anything to choose between them. Certainly rancid oleomargarin is a nasty and unwholesome compound; but not any more so than nasty and rancid butter, which abounds in so many markets. Both are unfit for human food, although both may be purified by well known processes." I would like to quote more from this admirable speech, but lack of time forbids.

Finally, allow me to call your attention to the remarkable absence of any reference to this food product by the most active and efficient State boards of health in this country. If there were such terrible dangers lurking in oleomargarin as has been so many times asserted, surely these boards of health have seriously failed in the discharge of their duty in giving so little attention as they have to the matter. A careful examination of the files of such reports as are in our university library fails to disclose any allusions of any importance whatever to the subject. Some of these States have prohibitory laws, and their reports extend back from five to fifteen years.

The whole question of the wholesomeness of oleomargarin as food is summed up in my own mind about in this wise: When properly made from fresh and clean materials it differs but slightly in healthfulness from butter; and this difference is only on account of its somewhat less easy digestibility; that dyspepsia, which has been attributed to it, is likely to be due to a far greater extent to other causes than this, even among those who, because of its cheapness as compared with butter, would be likely to use it largely; that it is possible that it may be made from such unsuitable materials that it will contain germs of disease, and that disease might thus be communicated to man; but that there is no positive proof that it is now made of such materials, or ever has been, or that any disease has ever been communicated to man by its use; but that the possibility exists, all the same, and the only way to make it of no effect is by careful inspection of the process of manufacture by capable officials.

To my statement that probably no other food product has been so much discussed with reference to its wholesomeness, I may also add that none has been so much specially legislated upon as this. Let us consider what is the present condition of this legislation.

New York being a great dairy State, and also, in the beginning, the great center of the manufacture of oleomargarin, was naturally one of the States in which special legislation began earliest. Two enactments in 1882 prohibited, (1) the coloring of the product to make it resemble butter, or the sale of any such colored product; and (2) required that all packages containing any such imitation of butter or cheese be plainly labeled. In 1884 the manufacture and sale of such imitation were forbidden in a special section of a general dairy law. This was pronounced unconstitutional by the Court of Appeals; but another slightly different enactment in the following year was allowed to stand.

The constitutionality of this final enactment was decided on this ground: that when a product of manufacture is turned out so closely resembling some other product of which the manufacture is already established as not to be distinguishable from it by the senses, and is made for sale in the place of that substance, it is constitutional to prohibit the manufacture and sale of it. But if it is turned out in some different form, as, for instance, uncolored, then its manufacture and sale cannot be prohibited, except on plain grounds of injury to the health of the community.

At the close of 1885, Maine, Michigan, Minnesota, Missouri, New Jersey, Pennsylvania, and Wisconsin, besides New York, had laws prohibiting the manufacture and sale of oleomargarin or any kind of artificial butter made from other fats; and New Hampshire had a law that was practically prohibitory, requiring that all such imitation of butter should be colored pink. California, Colorado, Connecticut, Delaware, Ohio, Oregon, Rhode Island, Tennessee, Vermont and West Virginia had simply regulative laws, providing that the substance shall be sold under its own name.

At the close of the year ending June 30, 1891, Maryland had been added to the list of prohibitory States, and Minnesota, Vermont, and West Virginia had joined company with New Hampshire in requiring the pink coloration of the artificial butter, while New Jersey, Massachusetts, and Ohio prohibited the sale of it only if colored in imitation of butter. Of the other States, Arkansas, Kentucky, North Carolina, Tennes-

* A lecture delivered before the Franklin Institute, January 15, 1892.—*From the Journal.*

sas, Utah, and Washington had no enactments in regard to the matter. The remainder of the States, twenty-five in number, merely required that it should be sold under its own name and not as genuine butter. Abroad the laws are all regulative, and not prohibitory.

In 1886, the national law was passed, under the title of "An act defining butter, also imposing a tax upon and regulating the manufacture, sale and importation of oleomargarin." This act required every manufacturer to pay $600 for a license fee; every wholesale dealer not a manufacturer to pay a license fee of $480; and every retail dealer selling in quantities less than ten pounds to pay a fee of $48; and that every pound sold shall pay a tax of two cents. It was first attempted to make this ten cents, but by reduction to the lower figure, the enactment was saved from being practically prohibitory. President Cleveland approved the measure on the ground that Congress is justified in making oleomargarin a subject of internal taxation; that Congress may clearly levy such taxes as will confer incidental advantages on the people; and that no industry is better entitled to such incidental advantages as may follow this legislation than our farming interests; and that the quality of the article will come under more strict scrutiny, so that only a good and clean product will be sold; and, finally, the product will be sold under its own name, and fraud and imposition will thereby be suppressed.

Recalling to mind some of the extravagant statements in Congress in support of this measure, or especially of the ten-cent clause of it, the comment on it as passed by a prominent agricultural paper is appropriate: "That if oleo is as bad as it has been painted, the new law will make the government a party to the crime of permitting an unwholesome article, and its action is, therefore, simply and purely a compromise with the devil." I wonder how many actually believed that it was as bad as it was painted.

What has been the motive in the passage of the sundry enactments concerning oleomargarin? Was it for the preservation of the public health or for the preservation of another industry? The speech of the chairman of the committee, above referred to, in which the passage of a restrictive bill was asked for, covered twenty-eight pages of print, of which only four refer to the public health. The great burden of the speech is the harm that is being done to the dairy interest by the secret trade in oleomargarin. Such statements as these are prominent: "A great and important industry of this commonwealth and of the nation of which we are a part, is imperiled. The industry imperiled is the American dairy." "The dairy to-day lies prostrate at the feet of this new butter king." Over against all this and more on this phase of the question, all that was said in the speech concerning the question of wholesomeness, was uncertain in tone, and wisely so since so little proof could be adduced of the danger to health by its consumption.

In 1884, when the prohibitory bill was before the Senate, the burden of the argument for it was again the pecuniary loss caused to the dairy of from $5,000,000 to $10,000,000 per annum. The sanitary side of the question was just touched upon, reference being specially made to the use of nitric acid in the rendering of the lard, which chemical, it was said, is a poison; but the committee could only state in general terms an opinion that the oleomargarin is likely to be unwholesome.

In reference to the prohibitory law of Pennsylvania, the Supreme Court affirmed its constitutionality, saying that "The manufacture and keeping of an article may alike be prohibited by the legislature, if in their judgment the protection of the public from injury and fraud requires it." "The fact that the prohibited article may be innocuous is irrelevant; the sale of a mixture of pure water and milk has been prohibited." Here again the question of the public health is not taken into account. Of the same character was the decision of the Missouri Court of Appeals, on the constitutionality of the prohibitory law there; nothing was said about the public health. In the case of the almost frantic appeals sent out from Washington at the time that the practically prohibitory bill with the ten-cent clause was pending, it was the farmers of the country who were called upon to work upon their representatives directly, and upon the Senate through their respective legislatures, to secure the sufficient support of the bill in Congress.

So I might go on, adducing other evidence in support of my contention that the consideration of the public health has had very little weight in the minds of the ardent advocates of these prohibitory laws, or of any other legislation on oleomargarin, and that the money question was the real one at issue. Not a few protests have appeared from time to time against such proscriptive legislation, even in the agricultural press. One of the most prominent dairy writers in the country, writing before the passage of these laws, said, "There is no law and there can be no law to prevent its sale for what it is." Another, who while he lived was esteemed as among the highest authorities in the country on dairying, when asked if the manufacture of oleomargarin should be prohibited by law, answered: "By no means. Its manufacture is as legitimate as that of butter. Its manufacture is actually a blessing. On the one hand it is suppressing the lower grades of butter, and on the other hand it makes the finer brands of creamery butter more sought after. There is nothing for the dairymen to fear in it. Their safety can be insured by improving their butter product."

What has been the effect of this stringent legislation on the extent to which the product is manufactured, on its quality, and on the interests of the class of producers for whose benefit the laws have been enacted? It would naturally be expected that the first effect would be one of marked depression in the quantity made in some States and of increase in others where no laws were made. It was stated in the New York legislature by the chairman of the committee already many times referred to, that in 1888, 20,000,000 pounds were made in that State alone. This estimate is confessedly to a large extent guess work. As to the total production in the country at any time previous to the passage of the national law, there appear to be no reliable data. It was wildly stated to be 200,000,000 pounds; it was admitted by those not interested in making the estimate excessively high that the amount may have been half as great. For the fiscal year ending June 30, 1886, it was estimated on the basis of data claimed to be reasonably sound to be about 33,000,000 pounds. In the following year it was nearly 35,000,000 pounds; in the next year, 35,664,000 pounds. During the year ending June 30, 1891, 44,000,000 pounds were produced; and the great manufacturers, Armour & Co., of Chicago, predict a still larger output for the year ending June 30, 1892.

It is interesting to see where the manufacturers are, and also where the oleomargarin is consumed, the location of the retail dealers giving us very reliable information as to this last point. Concerning all of these matters the reports of the Commissioner of Internal Revenue furnish sufficient data. In 1889 there were twenty-three manufacturers, distributed as follows: Colorado, 1; Connecticut, 6; Illinois, 7; Indiana, 1; Kansas, 2; Maryland, 1; Massachusetts, 1; Ohio, 2; Pennsylvania, 2; the last mentioned notwithstanding her prohibitory law. The other part of the story, about where it was eaten, is somewhat startling. Of the whole number of States, only eleven were not mentioned in the list of those having retail dealers within their borders. Of these eleven only three—Delaware, Maine, and Minnesota—had prohibitory laws. As to the rest, beginning with the State having the largest number of retail dealers, Illinois had 1,091; Massachusetts, 400; Connecticut, 424; Michigan, 387; Ohio, 362; Missouri, 258; Pennsylvania, 157; Kentucky, 116; then follow the other States with numbers ranging from eighty-five down to one. Two bold firms even dared to open shops for the sale of oleomargarin in my own State, in 1887, another was added in 1888, and all three were there in 1889.

But what shall be said of the condition of the matter in some of the other States with prohibitory laws? Missouri was the first to have such a law, and even you Philadelphians had in that year twenty-five dealers in your very midst, and 157 in the whole State; and you have a prohibitory law, too, that your courts have pronounced constitutional. Michigan, with her prohibitory law, also had 387 retailers of "the vile stuff," as our dairy commissioners are accustomed to call it; Wisconsin, another prohibitory State, had 85 dealers, and New Jersey, still another, had 75. As for New Hampshire, her 47 retail dealers who have been in operation since 1887, had probably learned how to color their oleomargarin butter such a delicate pink that it would not be noticed by the unsuspecting boarder; but still enough to comply with the law; or do they come out in bold defiance of a very natural prejudice against pink butter, and color it deeper than ever the brightest carnation showed?

Another interesting feature of the statistics given in the commissioners' reports is the steady increase in the total number of retail dealers, from 2,316 in 1887–88 to 5,914 in 1890–91. In Missouri, the number increased to 627, or more than double what it was in 1889. In Pennsylvania, the number had risen to 1,100, and there were, besides, 2 manufacturers and 59 wholesale dealers. Only four States paid, in 1890–91, a larger share of the revenue on oleomargarin collected by the government than did Pennsylvania; those States being Connecticut, Illinois, Kansas, and Ohio; of this, $46,000 was paid at Pittsburg.

In New York the law is well enforced with the aid of a large appropriation and many officials. All the usual channels by which this oleomargarin is liable to enter the State are carefully watched and a few convictions are made each year. One of the discoveries thus made in 1890 was on a small island in Long Island Sound, where "the vile stuff" was found in a room used mostly for storage of rubbish—300 pounds of it packed in the bottom of an old ice chest, covered several layers deep with potato bags, and then the box itself covered with bags and old boxes. The proprietor was arrested, pleaded guilty and was fined $100.

These figures as to the consumption of this food product in the country seem to indicate that there was not a hearty public sentiment behind the noisy clamor that urged many of these enactments on to their passage. This view of the matter is strengthened by the fact that so few of the more influential agricultural papers and of the best writers for these papers were in favor of prohibition; at least such was the case in my own State; and it is only reasonable to suppose that they voiced the feeling of the majority of the farmers for whose supposed benefit this commotion was raised. What the best part of the press and the most intelligent part of the farmers wanted was simply a law requiring that these oleomargarin productions should be sold under their proper names; that there should be no cheating or deception, but that everything about this new business should be open and above board. Then they would have nothing to fear from it.

As to the quality of the product now, as compared with what it was in the first years, such a comparison cannot be made with any degree of satisfaction, since we have so few reliable data, based on official inspection of the manufacture or of the product. President Cleveland gave this as one reason for his approval of the national law, that the quality of the article will come under more strict scrutiny, so that only a good and clean product will be sold. But it cannot be said that this hope is justified. In the first report of the commissioner under the new law, the inspectors in some cases stated that they had examined into the character of the materials used at the factory, and they found everything as it should be. But since that time I find no evidence in any of the reports that any attention is given to this matter by these inspectors.

As to the effect of the legislation on oleomargarin on the butter product, it is also very difficult to reach any satisfactory conclusion. Many assertions have been made as to the depression in prices of butter caused by the introduction of oleomargarin, and *vice versa*; but there are very few carefully prepared figures in support of this assertion. On the other hand, in 1882, a comparison was made between the prices of butter in January and July, for the five years from 1857 to 1861, inclusive, before the war, with those of the corresponding months of 1877 to 1881, inclusive, when oleomargarin was actively made and sold; the average price was three cents a pound higher in the latter period for the best butter; and in the last two years of each period, it was seven to eight cents higher, with oleo sold under very little restriction. This statement was published in that stanch agricultural paper, the *Rural New Yorker*, and commented upon as indicating little benefit to dairymen from the prohibitory law. Elgin, Ill., is claimed to be the headquarters of the finest creamery butter, selling at forty to sixty cents a pound to the consumer. In January and February, 1886, the wholesale price of butter at the factory was nearly two to five cents a pound higher that it was in January and February, 1887; that is, a few months after the law went into effect, butter fell in price instead of rising, much to the chagrin of some speculators who bought largely for a rise.

The New York dairy commissioner, in his report for 1887, claims that the enforcement of the law in that State has encouraged dairymen to feed better, and produce a larger amount of butter, for which a higher wholesale price has been paid, while consumers have had to pay but little if any more, and from his figures he estimates that the net gain to the dairy producers in the United States during the two years ending November 30, 1887, was $40,000,000.

These and other statements indicating large gains for the dairy industry by the suppression or restriction of the manufacture of oleomargarin do not seem to be borne out by the following table, taken mostly from the report of the commissioner above mentioned for 1889, representing the receipts and value of butter handled in New York City for nine years:

Year.	Total Amount.	Total Value.	Price Realized.
	Pounds.		Cents per pound.
1881–2	79,864,840	$23,025,295	29
1882–3	90,547,910	22,627,579	24
1883–4	88,117,170	20,342,372	23+
1884–5	93,566,850	19,502,977	21—
1885–6	93,701,520	20,925,537	22+
1886–7	93,712,480	21,357,988*	23—
1887–8	95,242,360	22,065,219	23+
1888–9	108,477,260	23,386,456	21·5
1889–90	97,655,160	18,109,142	18·5

The net gain to producers whose butter was handled in New York City in the two years ending November 30, 1887, was $1,859,011; whether it is safe to estimate from this that the gain over the whole country for that period was $40,000,000, I leave for others to judge. The heavy fall in the prices realized for butter in the last two years of the seven shows that other causes affect this price besides competition with oleomargarin; the unsoundness of conclusions based on one set of statistics alone of the trade in one city should also be taken into account.

But the butter industry is threatened in other ways. A German chemist has found means to purify fat obtained from some tropical plants in such a way that it will keep well and can be made into an imitation of butter. A company has been formed in the Netherlands for the manufacture of this butter; and the editor of a prominent journal established for the purpose of exposing adulterations of food called for the preparations of several articles for the table with this butter—he being a member of one of the juries of the exposition where this butter was shown. The universal judgment was that it was excellent, and should bring the highest price. The editor of the paper from which this is taken says that one must keep a watchful eye upon this new industry, in order that at least this vegetable butter cannot be used for the adulteration of genuine butter.

Further, the attention of the Department of Agriculture has very recently been called to a more serious mode of adulterating butter than by the use of either oleomargarin or the vegetable butter. A substance, called "gilt edge butter compound," was received indirectly from the Planet Manufacturing Company, Wichita, Kan., with the statement that by taking equal parts by weight of genuine butter and of milk or one pint of fresh milk and one pint of butter, and one gramme of this compound, two pounds of butter can be obtained. The process consists simply in making the genuiue butter first somewhat soft and pliable by warming and working it so that the churn dasher will go through it, and then churning the whole together, the milk being warmed to about 100° F., and the churn scalded so as to warm that; then salt and butter color are added. The direction is given not to work the product, but to put it away into jars in a cool place to harden. On analysis it was found that the genuine butter contained about 16 per cent. of water, while the sample of the counterfeit butter made with this genuine butter and with milk and the gilt edge butter compound contained almost fifty per cent. of water. It was learned on examination that this gilt-edge butter compound contained pepsin; and experiments that were made showed that this ferment gives to butter, by acting as an emulsifying agent, the property of taking up much additional water and that the rennet ferment will act in the same way. The whole process is a very inexpensive one for loading the genuine butter with a large additional quantity of water.

As a chemist, it may be expected of me to say something about the means of detecting oleomargarin in genuine butter. A complete study of the various methods for this detection occupies many lecture hours in the course to my students in chemical analysis. Very brief treatment of the subject must, therefore, suffice here. It was shown in the beginning of my lecture that the change in the properties of the fatty acids and their compounds, as we pass from one member of the series to another, is very slight; and that it is only when we compare members of the series that are widely apart that we have such wide differences as to enable us to distinguish or separate them readily—differences in the melting point, solubility, or volatility. The fact that the fat of milk contains glycerides of two groups of fatty acids, thus widely enough separated from each other to give us marked differences in solubility and volatility, comes to our aid in distinguishing the butter from nearly all other fats, both animal and vegetable; it is the one quality of butter that enables us to make use of chemical analysis in the detection of the adulteration of butter with other fats.

Butyric acid and its three associates in butter are soluble in water and can be distilled without decomposition; palmitic, stearic and oleic acids are quite in-

soluble in water, and are completely broken up if we attempt to distill them. Therefore, we have only to get the fatty acids out of the glycerides by saponification and decomposition of the soap by a mineral acid, treat this mixture of the fatty acids with boiling water, and separate the soluble part from the insoluble by filtration, and dry and weigh what is on the filter. The highest per cent. of these insoluble acids that is allowed to exist in genuine butter fats, on the basis of a large number of determinations that have been made, is ninety; in oleo oil, tallow, lard, cotton seed oil, we have from ninety-three per cent. and upward. When butyric acid and its associates are separated out by distillation in the manner already explained, we can estimate their amount by measuring the acidity in the distillate collected; this measurement being now always expressed in the number of cubic centimeters of a one-fifth normal solution of sodium hydroxide that is required to neutralize the volatile acids obtained from two and one-half or from five cubic centimeters of butter fat. This number, which we may call the Reichert number, after the name of the chemist who discovered the method, ranges for genuine from ten upward for two and one-half grammes of butter fat, or twenty upward for five grammes of fat. The highest number for oleo oil, lard or tallow is less than one, and for cotton seed oil and cocoanut oil seven.

By these means there is not the slightest difficulty in distinguishing pure butter from pure oleo oil, or the other preparations of a similar character; nor is it difficult to distinguish butter adulterated with, perhaps, fifty per cent. of oleo oil and upward, but the results are not sufficiently positive for adulteration with lower amounts. Furthermore, since some animal oils that can be procured in quantity have been found to contain so large a proportion of these glycerides yielding volatile fatty acids that, by the addition of them to oleo oil, the Reichert number can be brought up to that for genuine butter, with little difficulty, our dependence on either of these two methods for detecting the adulteration may yet be made very insecure. For instance, porpoise jaw oil has been found to yield a fatty acid mixture by saponification, and so on, of which the Reichert number ranges from forty-six to sixty-six; it needs only that this oil shall be so refined as to deprive it of its fishy taste and odor, in order that it may be used to put chemists entirely off the scent, in the use of their analytical methods for the detection of adulteration with oleomargarin.

A multitude of simple tests have been proposed from time to time, and of such a very simple character that any one can make them with the simplest of appliances; but they have little value, being usually quite unreliable, and no conviction could ever be based on any one of them, or on all of them combined. One of these, simple in execution, though not in appliances, since it requires the use of a good microscope, depends on the fact that when a fat solidifies from a state of fusion, crystals are formed which, viewed by polarized light under the microscope, show a distinct play of colors or other very characteristic appearances. The process of manufacture of oleo oil in any of its forms involves in all cases the melting of the fat. Butter, unless exposed to unusual heat, is never melted; hence, normal butter will never present this phenomenon under the microscope with polarized light, while any fat refined by the application of heat, at any time during the process of its manufacture into imitation butter, will always show it.

This simple method has been severely criticised; for it has been shown that under some rarely occurring circumstances oleomargarin may possibly not exhibit the phenomenon, and that butter although perfectly genuine may have been some time just enough warmed to be partially melted, and then it will exhibit the phenomenon described. Nevertheless this test can be and is used by the inspectors of the Internal Revenue Bureau, specially adapted microscopes being supplied to them; but it serves only to indicate suspicious cases; a sample thus indicated as suspicious is subjected to analysis before any action is taken concerning it.

To sum up what appears to me the fair position in regard to oleomargarin: It is a food product unquestionably. No legislation can rule it out of the list of food products. Taken into the system it follows the same course that butter does, is changed in the same way, if not perhaps quite so completely; is taken into the circulation, and then serves precisely the same purpose that butter does. When properly made from proper materials it is entirely harmless, except possibly when consumed as freely as butter would be by persons with weak digestive powers.

While it is claimed by manufacturers that a good artificial butter cannot be made, if fats are used that are not clean and wholesome at the start, it may not be that this is fully established. But, on the other hand, it must be granted that there is no evidence that any community in which artificial butter has been used, even freely and without any official inspection or restriction, has been any the worse for its use in respect of health, either individually or collectively. These being the facts in the case, it is not surprising that many regard as unjust any legislation that prohibits the manufacture or sale of this substance, whether directly, or by such ridiculous subterfuges as require it to be colored pink or any other abnormal color; the chief motive, nay almost the only real motive for this legislation being that of attempting to save another industry, working along the same line, from pecuniary damage. On the other hand, oleomargarin is not butter; and it is wrong to sell it as butter, no matter how good the imitation may be. Probably its manufacturers and dealers have brought all this trouble on themselves in the way of prohibitive legislation, by their attempts to sell it as butter; if from the first it had been sold under its own name, I very much doubt whether any prohibitory law would have been enacted in any State. All over the civilized world, general or special laws exist, prohibiting the selling of anything for what it is not; no one denies the need or equity of these laws; their purpose is to protect honesty against dishonesty, and to give every honest man a fair chance, whether he be a seller or a buyer.

When a man sells oleomargarin as butter he is violating these laws; and in proportion to the ease with which the imitation can be palmed off for what it is not, and in proportion to the value of other industries that are injured by such deceit, should be the efficiency of the means for the detection of the fraud, and the severity of the penalties imposed upon it; so that the producer of the genuine article shall not need to go far out of his way for the means of defense. Therefore, laws requiring that oleomargarin shall be sold for what it is are just laws, I care not how stringent they may be.

Furthermore, there is work for boards of health in connection with the trade in this food product wherever it is permitted; especially should its manufacture be watched. This needs to be done at least till it has been fully established that only clean fats from animals killed in health can be used for its manufacture. The large license fee required of manufacturers throws the manufacture into comparatively few hands, and such inspection is thus rendered comparatively easy.

Under such restrictions it seems to me that the trade in this article might safely be left to itself, and that it might be a blessing to the community as a whole in supplying at low prices a savory substitute for butter, far better in quality than most of that which the poorer classes have to eat, if they can get only genuine butter; and for those who can afford to pay for good butter, the opportunity to get it will be better, for dairymen will be obliged to make good butter if they make it at all.

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